How to Enhance the Efficiency and Effectiveness of Tutorial System in the Digital Era

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***Abstract*—Faculty-mentored research experiences under tutorial system are acknowledged as a critical way in cultivating university students' comprehensive skills, especially the research capabilities and application of scientific English. However, the implementation effect of current undergraduate tutorial system in domestic universities is disappointing. The primary objective of this research is twofold: to investigate the problems of the current tutorial system used in domestic universities; and to design the reform scheme that overcomes these problems efficiently and effectively. We design a questionnaire with multiple-choice questions and open questions, which is administered to freshmen, sophomores, junior, and senior students in G University. We also collect data from faculty members and administrative officers. Based on the feedback from students and staff, we identify the problems of the current tutorial system, the concerns of students, and the expected guidance from tutors. We notice that different mentoring strategies should be applied to students in different university years. Under the instruction of Chinese-style education modernization, we propose a technology-enhanced tutorial system reform scheme. It is generally known that there is no one-size-fits-all solution to address all practice issues for all universities. With this in mind, we further discuss the adjustment strategy in response to technological advances and diversified running objectives.**

***Keywords*—technology-enhanced tutorial system, higher education, education reform, digital intelligence**

I. Introduction

The tutorial system originated in Oxford University in the 14th century, and has gone through three stages: the original tutorial system period, the classical tutorial system period, and the modern tutorial system period. By the end of the 19th century, the modern tutorial system became a relatively procedural system which aimed at cultivating scientific research ability. Under this pedagogical mechanism, tutors are generally responsible for enlightening, guiding, and supervising students, through formal or informal individual counseling and group discussions; students are guided to mature mentally and develop research skills, including critical thinking, active learning, and problem solving. Therefore, the undergraduate tutorial system as practiced at Oxford University has been characterized as being 'a pedagogical gem, the jewel in Oxford's crown' and the best way to educate Oxford's high-quality young talents [1]. Nowadays, it is still regarded as one of the most trustworthy and effective teaching systems. Over time, the contemporary tutorial system has been given new meaning, and its form has been constantly evolving on the basis of the undergraduate credit system [2, 3]. By now, the undergraduate tutorial system has been applied by many internationally prestigious universities around the world, such as Cambridge University, Harvard University, Birmingham University, University of Rochester, Yale University, McGil University, Purdue University, Princeton University, University of Washington, Dalhousie University, etc.

The acceptance and implementation of the tutorial system in China began in 1938. Zhejiang University combined the credit system with the tutorial system to construct an education program for undergraduate talent training. This institutional innovation was successively adopted by other domestic universities at that time, but was later replaced by the academic year system. Around 2004, China's major universities began to re-implement the undergraduate tutorial system, including Peking University, Tsinghua University, Zhejiang University, etc. For now, various types of tutorial systems are used, including the junior tutorial system, the senior tutorial system, the talent tutorial system, the course tutorial system, and the life-guidance tutorial system [4].

II. Literature Review

Up to now, the undergraduate tutorial system has been implemented continuously in China for nearly 20 years. The tutorial system, along with counseling system and class-teaching system, forms a Chinese characterized higher education system. Obviously, there are considerable differences in the division of responsibilities among counselors, class teachers and tutors. Counselors are mainly responsible for carrying out mental health education, moral education, and legal education. Class teachers are mainly responsible for offline and online teaching. Tutors are mainly responsible for guiding

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students in course selection, professional direction selection, and scientific research activities.

The implementation effect of current undergraduate tutorial system in domestic universities is disappointing, which has drawn attention from researchers in pedagogy. Literature shows that the undergraduate tutorial system in domestic universities has the following problems: (1) The positioning of the tutorial system is inaccurate, and its responsibilities are often overlapped with the class teacher system and the counselor system. In some universities, the class teacher concurrently serves as the tutor, due to lack of manpower [5]. (2) Due to the imbalance of the teacher-student ratio after the expansion of university enrollment, each tutor has to supervise many undergraduates at the same time. This leads to an embarrassing situation that tutors hardly have enough time to meet with students regularly or to give one-to-one personalized guidance [6]. (3) In the absence of explicit objectives, adequate supporting system, and effective supervision mechanism, both students and tutors gradually lose confidence in the tutorial system. In this case, the tutorial system turns out to be a mere formality [6]. (4) Domestic universities blindly imitate the Western-style tutorial system, but fail to carry out localization reform [7].

To overcome the above-mentioned problems, education researchers have proposed some solutions. Liu, Li, and Lin [8] suggest a "mentor-graduate-undergraduate" mode that introduces postgraduates into the mentor team. Hou and Wang [9] propose to quantify the tutor evaluation. Li [7] advises to practice mutual election between tutors and students. Other solutions include balancing the standard and flexibility when deciding on the tutor's responsibility [10]; concentrating superior resources on top-notched innovative talents with research self-efficacy, academic aspiration, and interests [10]; applying the precision tutorial system that combines standardization and individualization [11]; establishing a speciality guidance based on students' personality and academic background [12], etc.

However, the existing literature does not consider the development and application of 5G, big data, extended reality, and artificial intelligence in tutorial system. Therefore, the proposed suggestions in the literature barely have feasibility in practice. With the help of digital technology, coupling multi-source heterogeneous data, processing large-scale data, personalized teaching, and evidence-based evaluation become possible [13]. The application of advanced technology is also one of the connotations of Chinese-style education modernization [14, 15]. In this paper, we continue this line of research on undergraduate tutorial system reform and explore a feasible technology-enhanced solution. Our research may contribute to the mission of domestic universities, which is "to promote the in-depth integration of program-specific studies and foreign language training so as to nurture global-minded responsible person who is excellent in both ethical cultivation and academic achievement, strong in both cross-cultural communication and hands-on creativity, and with a deep love of the country".

III. The Context of Reform

The education reform in domestic universities is mainly driven by education policy and technological advances. Therefore, it is necessary to understand the national strategy of Chinese-style education modernization and the impact of digital intelligence on higher education.

A. Chinese Higher Education Modernization: Construct Internationalized First-Class Universities

Chinese higher education modernization has five connotations, namely innovation, openness, coordination, green, and sharing [14]. In particular, innovation is the first important connotation, embracing both localization and creativity. In terms of openness, it requires the construction of a new pattern of opening higher education. Coordination means that the development of higher education must be coordinated with the development of society, economy, culture, science, and technology. Last but not least, it is essential to take the road of green development and optimize the allocation of higher education resources.

Under this national strategy, domestic universities aim at the direction of internationalized university for its global-minded faculty and students. Moreover, most domestic universities have a robust system in place for coordinated sustainable development of both international languages and other non-language academic disciplines. With the mission of nurturing global-minded high-quality talents, the first-class universities actively implement bilingual teaching, encourage Sino-foreign cooperative education programs, and pursue international academic cooperation under the framework of the undergraduate credit system and tutorial system.

B. The Impact of Digital Intelligence on Higher Education

Digital intelligence has been constantly reshaping the higher education in recent years.

Firstly, it helps transform the traditional educational system of higher education institutions into a person-centered, blended, systematic adaptive educational environment. Some universities have carried out the construction of digital smart campus and established an integrated intelligent university administration platform. By applying Virtual Reality (VR) technology, big data, and artificial intelligence, education resources (online courses, electronic teaching material), talent training programs, and VR experimental training platforms have been developed. Tutors should help students understand these adjustments and innovations.

Secondly, it does not automatically enhance educational equity. As an important application of digital intelligence in education, online teaching was adopted nationwide in China due to the sudden outbreak of COVID-19. Based on the COVID-19 quasi-natural

experiments, research shows that online education may not be able to narrow the gap between students with different family conditions due to "digital divide" [16]. Without guidance from tutors on campus, the learning outcome of online education at home is limited by students' self-discipline spirit, network condition, home environment, etc. Therefore, tutors should not only improve educational efficiency, but also promote educational equity.

Thirdly, teaching evaluation has changed from the traditional perception-based evaluation to the modern evidence-based evaluation. This new evaluation method focuses on the whole process of teaching. By coupling multi-source heterogeneous data, it is viable to analyze the teaching input and learning effects. Moreover, it can explore the blind spots of traditional education evaluation, and eventually reconstruct the new ecological system of learner-centered assessment [13]. Therefore, evidence-based evaluation method has a significant advantage over the traditional method. It should be introduced in the assessment of tutors' performance.

IV. Methodology

In order to propose a feasible solution, we have to firstly reflect on the current tutorial system in domestic universities based on our work experience, secondly identify the practical problems and investigate the students' diversified demands, and finally design the technology-enhanced reform scheme.

The investigation is conducted among 597 undergraduates in F School of G University, including 149 freshmen, 151 sophomores, 147 juniors, and 150 seniors. To understand what concerns students most in different university years and what kind of guidance they need from the tutors, we designed the questionnaire with relevant questions and surveyed students anonymously. To avoid limiting the possible response, in addition to multiple choice approach, the responses can be given in free text. Before the full survey, a pilot survey is carried out to ensure that the questions are unambiguous.

In addition to students, 51 faculty members and 42 administrative officers from various departments are also interviewed to collect opinions and suggestions on the current tutorial system. To raise efficiency, a number of techniques have been used to identify the practical problems of the current tutorial system, including brainstorming, independent group analysis, Delphi technique, and group workshops. Specifically, the Delphi technique starts with an initial survey, followed by subsequent surveys which are based on the initial responses.

V. Investigation Results

A. Investigation Results: Students' Demand

Tables I and II summarize the investigation results.

TABLE I. The Most Important Concerns of Undergraduates

Classification	Top 3 issues of concern		
Freshman	Learning method	Professional direction selection	Adapt to university life
Sophomore	GPA (grade point average)	Academic competition	Professional certificate
Junior	GPA	Academic competition	Internship
Senior	Postgraduate entrance exams; Civil servant recruitment exam	Seek employment	Study abroad for further education

TABLE II. Students' Expected Guidance from Tutors

Classification	Expected guidance from tutors
Freshman	1. In the transition from high school to university, learning methods should be adjusted in accordance with the curriculum. 2. Following completion of the university foundation year, students continue with sub-specialty education programs. The students expect to get guidance on which specialty is suitable for himself/herself. 3. University life may be the last stage before students enter society. How to make full use of this period of time?
Sophomore	1. GPA is important for seeking employment or pursuing further study. How to do self-motivation and improve GPA. 2. To develop scientific research potential, students are encouraged to participate in academic competitions, research projects, etc. How to balance the course study and research activity? 3. Which professional certificates or English certificates are valuable? How much time and money does one need to invest in?
Junior	1. Professional core courses are relatively harder than foundation courses. How to get support material and improve GPA? 2. Juniors usually have opportunity to lead competing teams. How to seize opportunities and win the awards? 3. Most students have interest in doing exchange learning and internship. Which one will have positive influence on personal development?
Senior	1. Because of the poor economic situation, many students want to find a stable job after graduation, such as, work in state-owned enterprises or government job. How to apply for these jobs? 2. How to prepare for postgraduate entrance exam and civil servants' exam? How to do time management? 3. If economic conditions allow, many students plan to study abroad. What are the application procedures? How to prepare for the required documents?

B. Investigation Results: Practical Problems of Current Tutorial System

Specifically, these practical problems are as follows:

Problem 1: In terms of responsibility, the tutor actually serves as a triple role of counselor, class teacher, and tutor. The scope of responsibility of the tutor is too broad to work out.

Problem 2: In comparison, the science and engineering majors emphasize on mathematical analysis and practical skills; and the humanistic and social science majors emphasize on logical thinking ability and qualitative study. Currently, the tutor's responsibility and guidance methods do not vary in accordance with students' major, which results in disappointing effects.

Problem 3: Students' interests and demands are diversified, personalized, and evolving over time. For example, freshmen should adapt to new university life; sophomores should take the opportunity to participate in competitions and research activities; juniors are busy with specialized courses, research projects, and student communities; senior students have to do internship, seek employment, and pursue further education. Tutor's responsibility and guidance method have not taken students' backgrounds and university years into consideration.

Problem 4: The tutors rotate among undergraduate classes, once in each academic year. This means that the tutor supervises each class for at most one year. It is impossible to maintain a long-term sustainable guidance relationship between tutors and students.

Problem 5: Each tutor has to supervise around 40 students. So, the tutors barely have enough time to conduct face-to-face guidance with each student regularly.

Problem 6: Tutors and students are rewarded for research outcomes and creative achievements, such as research papers, awards of contests and competitions, artistic creations, etc. However, the non-quantitative outcome is usually overlooked.

Problem 7: Compared with evidence-based evaluation, the evaluation based on subjective scoring is unfair, inefficient, and backward.

It is worth noting that some of the practical problems (Problems 1, 5, and 7) are similar to the common problems mentioned in the literature, and the others (Problems 2, 3, 4, and 6) have not received critical attention. Only if all the practical problems are addressed comprehensively, can the tutorial system fully play its due role. Moreover, the reform scheme is not a one-size-fits-all solution to all universities, and should be adjusted in accordance with diversified running objectives. We will address the adjustment strategy in Section VII.

VI. Reform Scheme

In the digital era, with the help of advanced digital technology, the reform scheme that can both satisfy students' demands and address the practical problems is presented as follows:

- **Objectives and value**

A committee on undergraduate education in each school should be established to take charge of organizing the specific details of the tutorial system [17]. The objectives and values are as follows: (1) To improve the level of undergraduate education on both program-specific knowledge and foreign languages. (2) To offer guidance and advice on academic achievement and scientific research in accordance of students' aptitude. (3) To foster academic integrity and lay a foundation for lifelong learning.

- **Responsibilities and functions** (address practical problems 1, 2, and 3)

General principles: (1) It is necessary to redivide the responsibilities of counselors, class teachers, and tutors, so as to avoid overlapping. (2) For students majored in science and engineering, tutors should utilize multimedia, VR laboratory, and smart classroom, to train manipulative ability and logical thinking. For students majored in humanistic and social science, tutors should provide guidance in extracurricular reading, investigation research, and cross-cultural communication. For all students, data literacy and information literacy are essential skills in the digital age. (3) Since students' requirements vary and evolve, the tutors should adjust the strategy accordingly.

Responsibilities and functions: (1) Apply the 3-stage training mechanism to tap students' scientific research potential [18], i.e., scientific English study in freshman year, major-related core courses in sophomore year, and research training in junior year. (2) For freshmen, tutors assist in the orientation of the student towards university life. For sophomores and juniors, tutors help students with course study, research activity, internship, etc. [19, 20]. For seniors, embedding lifelong learning skills and employability training is a priority. Tutors should offer advice in matters pertaining to seniors' career and further education [21]. (3) The guidance on course study, foreign languages, and research activity is compulsory, whereas the other responsibilities are optional. In addition to undergraduate courses, the tutors should help students get access to distinct foreign language education resources.

- **Selections and appointment of tutors** (address practical problem 4)

Fulltime faculty members are encouraged to serve as tutors. The G university requires young teachers (aged below 40) to complete at least 1-year tutoring work before applying for promotion. Appointments are made on an annual basis, subject to renewal under certain conditions. For the consideration of education quality, each tutor may be assigned no more than 3 groups of students. In the case that the research projects last more than 1 year, tutors can continue guiding students until the project is completed. Due to the imbalance of the teacher-student ratio, it is essential to develop digital system that could provide information consulting services and release manpower.

- **Composition of student groups** (address practical problem 5)

Data-driven technology can generate digital portraits for tutors and students based on various characteristics,

such as education background, academic work experience, research interests and outcomes, awards, etc. (for tutors); basic information, academic achievements, major, discipline, etc. (for students). Then, the digital portraits can be applied in two-way choice between tutors and students. The interdisciplinary cooperation is encouraged, so the groups can be mixed. Each group may have 3 to 5 students with different majors. Besides, we should be aware that mentoring helps foster students' identity. In return, students' identity has an impact on the communication, grouping, and mentoring quality. Therefore, the interaction between mentoring and students' identity should be emphasized.

- **Frequency and duration of meetings**

It is inappropriate to make it mandatory for tutors to talk with every student at least 3 times per semester. For instance, seniors are normally off campus to do internship and they do not have time to meet with tutors regularly. Therefore, tutors and students are allowed to decide the frequency and duration of meetings. If talking in person is not convenient, online meeting is a second option.

- **Student attendance**

It is not compulsory for students to attend group meetings. Students can contact tutors to discuss about issues related to education, research, and career. For other personal problems, students can refer to counselors and class teachers for help. The freshmen are encouraged to attend meetings regularly and frequent absence is not acceptable. For sophomores and juniors, they should consider fully before joining a group, and cannot withdraw from research project without explanation. Seniors are usually busy with internship, job-seeking, and further education, so they may get exemption from attending group meetings.

- **Supporting measures and rewards** (address practical problem 6)

Faculty-mentored Undergraduate Research Experiences (UREs) are increasingly becoming a key component of baccalaureate education in Science, Technology, Engineering, and Mathematics disciplines [22]. The authors of Ref. [23–25] have reported that participation in UREs enhances student career clarification; research, communications, and critical thinking skills; understanding of research processes; and aspirations for graduate education and research careers. To improve university students' and homeschooling students' research outcomes, it is better to help students develop a more sophisticated understanding of the role of tutorials [26, 27]. As such, not only tutors but also university education committees should provide comprehensive support to students [28].

In the reform scheme, we suggest that students should be given a detailed introduction of the tutorial system from the very beginning of their university life. Students should understand the profound influence of tutorial activities and research experience. Besides, reasonable financial support and necessary facilities should be provided upon request.

- **Assessment of tutors** (address practical problem 7)

Evidence-based methods can provide high-efficiency, high-quality, and accurate evaluation results. The main steps are as follows: (1) Design evaluation procedures in accordance with responsibilities and functions of the tutorial system. (2) Set up a feedback system to collect opinions from the education committees, tutors, students, and other interested parties. (3) Apply digital intelligence system to collect, clean, store, preprocess, and analyze large-scale education data, then generate results automatically. (4) Utilize education data and evaluation results to explore key indicators, propose a diagnosis scheme, and guide practice. (5) Set up an early warning mechanism to prevent irregular actions. (6) Develop and adjust the category of excellence.

VII. Further Discussion

The proposed reform scheme in the previous section is not universally applicable. In practice, it may ought to be adjusted dynamically in accordance with the evolution of education technology and diversification of university missions.

A. The Evolution of Education Technology

The development and application of educational technology has a remarkable impact on education outcomes. In the early part of the 20th century, radio-based technique was introduced in teaching for remote learning [29]. With the advent of television and the introduction of personal computers, the remoteness or resource constraints were further eased [30]. Thereafter, the networked learning environments and highly interactive multimedia became widely accessible and affordable [31]. More recently, digital intelligence has received close attention from both academia and industry. Both teachers and students should actively adapt to the reshaped educational modes. It is not rare or surprising that new technologies will be introduced in educational reform in the future, therefore the tutorial system is driven to be improved consequently.

B. The Diversified Objectives and Missions of University

Based on statistics of the Ministry of Education of China, there are in total of 3013 universities, including 2759 regular higher institutions and 254 adult higher education institutions. The types of universities include comprehensive universities, normal universities, universities of science and technology, universities of liberal arts, etc. Different levels and types of universities differ significantly in orientations, objectives, missions, specialty, characteristics, etc. Therefore, the operation of the tutorial system varies from one university to another, in line with the objectives and missions of each university.

VIII. Conclusion

In this paper, we identify the problems of the current tutorial system in practice. Then we propose a reform scheme of tutorial system based on investigation results, aiming at enhancing the integration of program-specific studies and foreign language training. Taking advantage of digital intelligence, the efficiency and effectiveness of

the tutorial system can be greatly improved, and the university mission can be accomplished. We further discuss the theoretical and practical issues, including applicable conditions, necessary adjustments, and the impact of technological advances on the tutorial system. We will focus on this line of research and shape the research agenda for the future based on the latest research findings.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

Yan Zhang: conceptualization, writing-original draft, investigation, and supervision; Jia-Hui Huang: methodology, formal analysis, writing-review & editing; Jianmei Jiang and Kangmei Ling: data curation, writing-original draft; all authors had approved the final version.

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