The Reform and Practice of the Undergraduate and Graduate Integrated Curriculum based on the Algorithm Design and Analysis of Students' Psychological Needs

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Abstract: In response to the problem that the current curriculum content planning and teaching model for algorithm design cannot fully meet the actual needs of students, this paper analyzes the psychological characteristics and internal needs of students at different levels, develops curriculum objectives that match the psychological needs of students based on Maslow's hierarchy of needs theory. In addition, it sets up teaching content that reflects the hierarchy of needs, adopts teaching methods and techniques that deepen students' positive psychological experience, and designs assessment and evaluation methods that reflect students' diverse needs. The practice results show that the proposed curriculum reform plan improves teaching effectiveness and enhances students' innovation awareness and practical skills.

Keywords: Psychological Need; Hierarchical Demand Theory of Maslow; Algorithm Design and Analysis; Curriculum Reform

1. Introduction

In 1943, American social psychologist Maslow proposed the "Theory of Human Needs", which summarized human needs into physiological needs, safety needs, social needs, self-esteem needs, and self-actualization [1]. There is a progressive relationship between these needs. When lower-level needs are met, people will strive to achieve higher-level needs [2]. The theory of hierarchy of needs can guide teachers in developing appropriate teaching objectives and planning teaching content based on the learning foundation and needs of students at different levels. This approach can help stimulate students' intrinsic enthusiasm and learning in multiple ways, improve learning outcomes, and promote their comprehensive and healthy development. Algorithm design and analysis covers a wide range of disciplines, based on the foundations of mathematics, physics, and computer science, while also radiating into applied disciplines such as engineering and control. With the emergence of new technologies in the field of algorithm design, the development of related disciplines has been promoted through interdisciplinary, integrated, and penetrating approaches, driving the rapid development of algorithm design and analysis technologies. This course plays an important role in cultivating students' academic thinking, improving their research skills, and cultivating their innovation ability. However, learning the course well requires a solid foundation in mathematics, which makes many undergraduate students feel intimidated by the course and many graduate students feel difficult to gain a sense of accomplishment through course study. Guided by Maslow's hierarchy of needs theory, this article explores the teaching reform of the course "Algorithm Design and Analysis". Based on the hierarchy of needs theory proposed by Abraham Maslow, this article analyzes the problems existing in current teaching from the perspective of students' psychological needs, and explores ways to stimulate students' intrinsic learning motivation through integrated curriculum reform for undergraduate and graduate students, improving classroom teaching effectiveness, and enhancing students' professional literacy.

2. Problems in Course Teaching

2.1 The Setting of Teaching Content does not match the Psychological Expectations of

Students

There are too detailed introductions of background theories or popular science-based overviews of new technologies in undergraduate teaching. Many content in graduate courses is a repetition of what has already been learned in undergraduate courses, lacking in the improvement and extension of basic knowledge and scientific issues, and failing to form a curriculum system and a complete knowledge structure. Undergraduate students cannot acquire strong engineering practice skills through coursework, and graduate students' research capabilities have not significantly improved, failing to meet the psychological needs of integrating education with practicality.

2.2 The Curriculum Practice cannot Cultivate Students' "Self-Control" and" Sense of Control"

The self-determination theory [3] holds that individuals are active organisms with innate psychological growth and development dynamics, and people like to feel that they have control over things. Learning is a process of continuous exploration and climbing, and students need to overcome numerous difficulties in order to master true knowledge. Currently, most practical courses in algorithm courses tend to focus on validated experiments based on classical methods, which cannot track the latest research results, which is not in line with the widely recognized OBE [4] education philosophy and cannot track the latest research results. This makes it difficult for students to appreciate the "advanced" and novel aspects of the subject, and reduces their motivation to learn.

2.3 The assessment method does not reflect the psychological motivation effect

The examination content emphasizes theory over practice, and the process evaluation focuses on performance over motivation. The evaluation form is single and difficult to monitor. Students have little interest and participation, which cannot stimulate people's enthusiasm, initiative and creativity.

3. Curriculum Reform and Practice

3.1The Curriculum Goals are in Line with the Individual Development Needs of Students

Accurately analyze the needs of students at different levels, align curriculum goals with student needs, emphasize and analyze the overall teaching objectives of the curriculum and the teaching objectives of each stage, so that students can recognize the guiding role of the curriculum in their career choices and career development, and enhance their enthusiasm in achieving their learning goals.

The major differences in undergraduate algorithms design and analysis courses among Computer Science and Technology undergraduate majors, as compared with comparable courses offered for the same subjects, are outlined in Table 1.

Table 1. Comparison between courses of Postgraduate Students and Undergraduate Students

Distinguishing	Undergraduate student	Graduate student
Capability objectives	Engineering literacy, abstraction and modeling skills, basic application ability	Scientific research literacy, innovative thinking, and research ability
Knowledge objectives	Master the basic algorithm design concepts and analytical methods, and be able to use common algorithms to analyze and solve practical problems.	Master algorithm design and analysis methods for big data processing, closely follow leading edge knowledge and apply it flexibly in practice.
Teaching content	Divide and conquer, greedy method, dynamic programming, backtracking method, branch limit method	Parallel algorithm, stochastic algorithm, approximation algorithm, external memory algorithm, modern optimization algorithm
teaching model	Teach based, focus on the teaching materials, combined with cases for teaching and practice	Discussion based teaching, open experiments, and research-based experiments

3.2 The Teaching Content Reflects the Pertinence

Distinguish clearly between different teaching stages based on the depth and breadth of content. Emphasize the basic concepts of traditional algorithms for undergraduate students, while teaching the latest research progress in relevant research directions while teaching classical theory and derivation for

graduate students. Based on the analysis and verification of classical theories, exploratory scientific research practices are carried out, and the application and analysis of practical results in engineering projects are carried out to achieve the whole process from receptive learning to discovery learning to research learning. See Table 2 for specific teaching contents.

Table 2. Content and Knowledge Points of Graduate Courses

Content of courses	Main knowledge points
Parallel algorithm	Parallel computing model, expression evaluation, sorting network
Random algorithm	Random partition, random cache, packet routing selection
Approximation algorithm	Pricing method, linear programming and rounding, load balancing
External memory algorithm	External memory sorting, external memory searching, external memory data algorithm
Modern optimization algorithm	Ant colony algorithm, simulated annealing algorithm

3.3 The Teaching Process Cultivates Autonomy and Psychological Resilience

Cross-platform teaching is widely used due to its advantages in expanding learning spaces. Research has shown that learners' awareness and participation in online learning directly affect learning outcomes. [5] Using multiple platforms to expand learning space, promoting research progress and open source materials from renowned laboratories, and setting up appropriate questions for students to engage in interactive discussions. Promote mutual communication, sharing, and reflection among students. Learning outcomes should be closely integrated with credit, assessment, or grade, to help students understand and compare their own learning outcomes or learning gaps with their peers, create an atmosphere of "competition and collaboration", and guide students to develop appropriate competitive awareness, thereby enhancing their participation and effort in learning.

Guide students to conduct advanced experimental exploration activities based on the goal setting theory [6], decompose typical algorithm cases into multiple small goals, satisfy students' "psychological challenges", and complete learning tasks one by one in a relaxed and pleasant atmosphere. Enable students to experience a sense of accomplishment in primary tasks, stimulate their interest and enthusiasm in learning, and reduce psychological burden and anxiety. In high-level tasks, students can correctly cope with setbacks, calmly face obstacles and difficulties in the learning process, and improve psychological resilience and resistance to frustration.

3.4 The Assessment Method Reflects the Incentive Effect

The purpose of curriculum evaluation should not only focus on the examination and evaluation of students' learning outcomes, but also make full use of the motivational function of evaluation to promote students' self-reflection, guide them to independently identify problems, and be able to consciously correct them. For undergraduate students, the learning outcomes should be guided and evaluated based on the concept of OBE (Outcome Based Education) [7]. Adopt a combination of summative and formative assessments, abandon the traditional examination method based on a single exam to determine final grades, and implement phased assessments of learning content [8, 9].

For graduate students, more emphasis should be placed on course learning and social practice to cultivate students. In terms of curriculum evaluation, the paper is not the only form of evaluation, and a multi-dimensional evaluation system should be adopted to evaluate academic performance. [10] In the implementation of teaching, we have designed graduation assessment scores that are weighted by the results of basic knowledge tests, literature review, scientific project research, thesis writing, and PPT presentations. The literature review examines students' basic research skills, while the scientific project research evaluates their innovative thinking and ability, while the paper writing and PPT presentation evaluate their research and presentation skills. Through the multi-dimensional curriculum evaluation established above, it is possible to conduct scientific evaluations of graduate students' research and

technical capabilities, and the evaluation results can be used to guide curriculum and teaching reforms.

4. Teaching Effect of Curriculum Reform

This teaching reform began in 2021 for undergraduate students in 2019 and 2020, and graduate students in 2021 and 2022 at Beihua University. To evaluate the effectiveness of the reform scientifically, qualitative and quantitative evaluations were conducted on undergraduate students in 2018, 2019, and 2020, and graduate students in 2020, 2021, and 2022.

4.1 Qualitative Evaluation

The course teachers used a questionnaire survey to allow students to self-evaluate the achievement of course objectives after the end of the course and after participating in graduation internships. Each course objective was evaluated by several assessment points, with five levels of evaluation: fully achieved, well achieved, achieved, basically achieved, and not achieved. From the analysis of the survey results, it can be seen that the level of satisfaction with course teaching has significantly increased among the 2019 and 2020 undergraduates and the 2021 and 2022 graduate students who have implemented the teaching reform since the implementation of the reform. Especially, the post-graduation survey results of the 2019 and 2021 undergraduates and graduate students show that the level of satisfaction with course teaching is significantly higher than that of students who have not undergone the reform. The satisfaction level is higher than before the end of the course. It can be inferred that after the course is completed, students will be able to grasp the main content of the course and apply classroom theory to practical applications. The specific evaluation results are shown in Figure 1 to Figure 4.

4.2 Quantitative Assessment

Quantitative evaluation is guided by curriculum objectives and emphasizes student process assessment. Undergraduate students will be established with a diversified assessment system that includes classroom tests, classroom interaction, homework, course-based extended papers, and final exams. The proportion allocation of each assessment method is shown in Table 3.

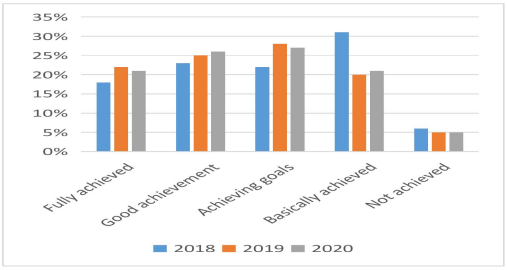

Figure 1. Undergraduate Self-Evaluation Results at the end of the Semester

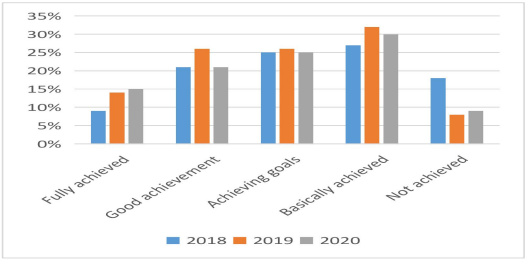

Figure 2. Self Evaluation Results of Undergraduate Students during Internship

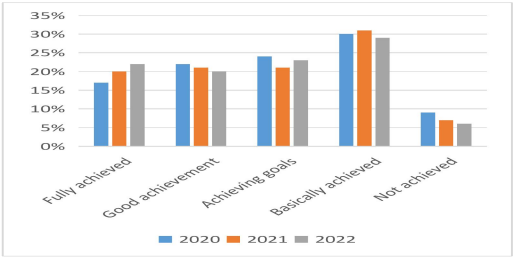

Figure 3. Graduate self-Evaluation Results at the end of the Semester

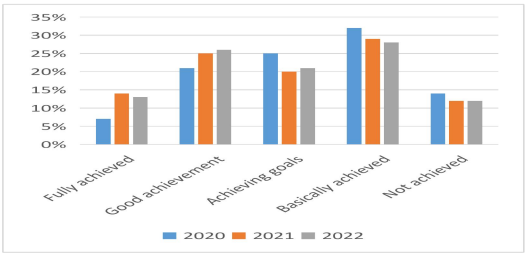

Figure 4.Self Evaluation Results of Graduate Students during Internship

Table 3. Proportion Distribution of Undergraduate Course Assessment Methods

Course objectives	Usual performance	Homework	Course Thesis	Course Quiz
understand the basic theory of algorithm	5	5	5	5
Basic algorithm optimization methods	5	2	5	8
Solve simple application cases	8		10	10
Conduct efficiency analysis of the solution	16	8		8
Total	34	15	20	31

Graduate students use project presentations and special seminars as a vehicle to assess their mastery of basic knowledge, literature search ability, scientific project research ability, and document writing ability. The focus is on enabling students to analyze the architecture and implementation mechanisms of algorithms, and to apply the basic principles of algorithm design and analysis to solve practical engineering problems and conduct theoretical analysis. Comparing the final examination scores of the 2020, 2021, and 2022 graduate students majoring in software engineering at Beihua University, the average scores of the students were 80, 85, and 86, respectively. In addition, two students in the 2021 class have published academic papers on relevant intelligent algorithms in important journals after the completion of the course. Six students in the 2022 class have obtained support from the school's graduate innovation program for their algorithm research plans. These achievements are the best among all previous graduate students, and the curriculum reform has achieved initial results.

5. Conclusion

Algorithm design and analysis covers a wide range of disciplines, relying on the foundations of mathematics, physics, and computer science, while also radiating into applied disciplines such as engineering and control. Guided by Maslow's hierarchy of needs theory, curriculum reform is carried out based on the learning foundation and psychological needs of students at different levels. Incorporating motivational methods into the teaching process, guiding students to understand individual development and learning patterns, and enhancing their self-learning ability and psychological resilience are effective means to cultivate high-quality, professional and psychologically healthy algorithm talents.

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