

Exploration and Practice of the "Three-Stage Progressive" Teaching Reform of Python Programming Course from the Perspective of Integration of Specialization and Innovation

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Abstract

The deep integration of professional education and innovation and entrepreneurship education is an important direction of current higher education reform. Taking the Python programming course for the Data Science and Big Data Technology major as the research object, this paper constructs a "three-stage progressive" teaching reform model of integration of specialization and innovation to address the problems of disconnection between professional knowledge and innovation and entrepreneurship, as well as insufficient cultivation of innovation ability in traditional teaching. The model takes "cognition-ability-innovation" as the evolutionary main line, and achieves the coordinated cultivation of professional competence and innovation and entrepreneurship literacy through teaching strategies such as hierarchical task-driven learning, enterprise case-based immersive teaching, competition-course integration, and university-enterprise dual-tutor collaboration. Practice has shown that the "three-stage progressive" model effectively improves students' programming ability, problem-solving ability and innovative practice ability, providing a referable path for the integration reform of specialization and innovation in computer science courses.

Keywords

Integration of specialization and innovation; Python programming; Three-stage progressive; Teaching reform; Innovation and entrepreneurship education.

1. Introduction

The integration of professional education and innovation and entrepreneurship education has become an important direction of curriculum reform in colleges and universities with the rapid development of information technology and the deepening of innovation education. The General Office of the State Council's "Guiding Opinions on Further Supporting College Students' Innovation and Entrepreneurship" clearly proposes that innovation and entrepreneurship education should be run through the entire process of talent cultivation and that professional education should be deeply integrated with innovation and entrepreneurship education. In this context, how to organically embed innovative and entrepreneurial elements into professional course teaching and realize the implementation of "integration of specialization and innovation" from concept to practice has become an urgent issue in higher education reform.

The Python programming course is a core foundational course for the Data Science and Big Data Technology major, characterized by strong practicality, broad application scenarios, and ample space for innovation. As a general-purpose programming language, Python enables learners to move beyond tedious syntactic details and focus on solving business problems themselves. However, in current course teaching, there is a common phenomenon of "two skins" between the teaching of professional knowledge and the cultivation of innovation and entrepreneurship ability. Although students can master basic syntax and programming skills, they lack the ability to transform technology into innovative solutions. How to realize the organic integration of

professional education and innovation and entrepreneurship education in the Python programming course and cultivate students' "professional hard power" and "innovative creativity" is an important proposition that urgently needs to be addressed.

Taking the Python programming course for the Data Science and Big Data Technology major as the research object, this paper proposes a "three-stage progressive" teaching reform model of integration of specialization and innovation, systematically expounds its design concept, implementation path and practical effects, with a view to providing reference for the integration reform of specialization and innovation in similar courses.

2. Theoretical Basis and Realistic Examination of the Teaching Reform of Integration of Specialization and Innovation

2.1. Connotation and Value of Integration of Specialization and Innovation

Integration of specialization and innovation refers to the deep integration of professional education and innovation and entrepreneurship education. Its core lies in organically embedding the concepts, methods and ability cultivation of innovation and entrepreneurship into the entire process of professional course teaching, rather than adding independent innovation and entrepreneurship courses outside professional education. In essence, integration of specialization and innovation requires breaking down the barriers between professional education and innovation and entrepreneurship education, and simultaneously cultivating students' innovative thinking, entrepreneurial awareness and business literacy in the process of teaching professional knowledge.

At present, innovation and entrepreneurship education in colleges and universities has entered a new period of comprehensive integration with professional education, but as an emerging educational activity, it still has problems such as lack of systematization and isolated development separated from professional education. Promoting the effective integration of innovation and entrepreneurship education and professional education has become a key entry point for improving the quality of talent cultivation. Integration of specialization and innovation is not a simple superposition of courses, but requires systematic reconstruction at the levels of teaching objectives, teaching content, teaching methods and evaluation mechanisms.

2.2. Necessity and Dilemmas of Integration of Specialization and Innovation in Python Programming Course

The Python programming course has natural advantages for carrying out integration of specialization and innovation. First, the Python language itself is concise, efficient and widely used, covering everything from Web development and data analysis to artificial intelligence, providing students with broad space for innovative practice. Second, the requirements of the big data era for talents have been upgraded from simply "being able to program" to "compound talents who can solve complex problems", which requires the course not only to teach technical knowledge, but also to cultivate students' innovative thinking and business insight.

However, the current integration teaching of specialization and innovation in Python programming courses still faces multiple dilemmas. First, the teaching content focuses on grammatical knowledge and basic programming training, lacking effective connection with innovation and entrepreneurship scenarios. Second, the teaching mode is still dominated by teacher lectures and verification experiments, and students lack training in solving real complex problems. Third, course evaluation focuses on a single dimension such as code correctness, neglecting the assessment of students' innovation ability, teamwork and business thinking. Fourth, the depth of industry-education integration is insufficient, and there is a disconnect between course content and industrial needs and industry standards.

The above dilemmas show that the integration reform of specialization and innovation in Python programming courses cannot stop at superficial content supplementation, but requires systematic reconstruction from dimensions such as curriculum system, teaching mode and evaluation mechanism.

3. Construction of the "Three-Stage Progressive" Teaching Reform Model of Integration of Specialization and Innovation

In response to the practical dilemmas of integration of specialization and innovation in Python programming courses, this paper constructs a "three-stage progressive" teaching reform model. The model takes "cognition-ability-innovation" as the evolutionary main line, and relies on digital tools and university-enterprise resources to build a "learning-practicing-creating" spiraling upward closed-loop of cultivation.

References are cited in the text just by square brackets [1]. (If square brackets are not available, slashes may be used instead, e.g. /2/.) Two or more references at a time may be put in one set of brackets [3, 4]. The references are to be numbered in the order in which they are cited in the text and are to be listed at the end of the contribution under a heading References, see our example below.

3.1. Model Framework

The "three-stage progressive" model takes "cognition-ability-innovation" as the logical main line and constructs a progressive cultivation path from the acquisition of basic knowledge to comprehensive innovative application. Its design follows the laws of learning cognition and the generative logic of innovation and entrepreneurship ability, and specifically includes three progressive stages.

The first stage is the cognitive stage, which aims to consolidate students' Python programming foundation. This stage focuses on the systematic teaching of basic knowledge such as Python core syntax, data structures and file operations. Through the design of a hierarchical task chain of "basic programming exercises - small project practice - enterprise case analysis", students are guided to gradually complete the cognitive leap from code practice to scenario understanding and from scenario understanding to problem abstraction. At the same time, relying on digital learning platforms such as the Chaoxing Learning Platform, the learning behavior data of students are dynamically tracked to provide differentiated learning support for students with different starting points, thereby ensuring that all students can achieve the basic standard of programming ability.

The second stage is the ability stage, which focuses on the deepening of professional application ability. This stage expands the teaching content from basic programming to enterprise-level application fields such as crawler development, data visualization and machine learning, introduces real enterprise projects and subject competition real questions, and guides students to complete full-process project development under the joint guidance of校内 teachers and enterprise mentors. Through "real questions with real solutions" and "dual-teacher collaboration," the effective alignment of student ability training with industrial needs and competition standards is achieved, with emphasis on cultivating their comprehensive ability to solve complex engineering problems using Python technology.

The third stage is the innovation stage, which focuses on the sublimation of innovation and entrepreneurship literacy. This stage deeply embeds innovation and entrepreneurship elements such as business model design, business plan writing, and intellectual property application into course teaching, and guides students to create value based on their technical achievements. At the same time, students are encouraged to rely on innovation and entrepreneurship competitions such as the "Internet +" competition to promote the incubation

and market-oriented transformation of project achievements, striving to open up the cross-channel from "technical achievements" to "market value."

The cognitive stage lays the technical foundation, the ability stage strengthens professional application, and the innovation stage realizes the creative transformation of value. The three stages progress layer by layer and rise spirally, jointly constituting a closed-loop of "learning-practicing-creating" integrated ability cultivation.

3.2. Core Teaching Strategies

To achieve the effective implementation of the "three-stage progressive" model, the course team has constructed a systematic set of core teaching strategies from the dimensions of hierarchical task design, teaching scenario creation, competition resource transformation, guidance mechanism construction, and achievement transformation channels.

The first strategy is hierarchical task-driven learning. Teachers customize a "basic-professional-innovation" three-level task chain for students based on dynamic learning diagnosis data. Among them, basic-level tasks focus on grammar exercises and code debugging, professional-level tasks take real enterprise cases such as e-commerce log analysis and user behavior analysis as the carrier, and innovation-level tasks require students to independently complete a complete project development with commercial value. This strategy adapts to the differentiated foundation of students and effectively guarantees the programming ability pass rate of all students.

The second strategy is enterprise case-based immersive teaching. The course relies on university-enterprise cooperation resources to introduce real enterprise projects such as financial risk control systems and public opinion monitoring platforms into the classroom. Students solve complex problems through group collaboration, and simultaneously cultivate industry cognition and business thinking in technical practice, achieving the ability expansion from "being able to program" to "understanding business."

The third strategy is competition-course integration. The course embeds competition resources such as the Blue Bridge Cup Python group question bank and Big Data Challenge real questions into daily teaching. Teachers transform competition requirements into course assignment standards, and past competition achievements are incorporated into the teaching case library, thus forming a closed-loop ecology of "learning-competition-creation." The normalized mechanism of "promoting learning through competition and promoting teaching through competition" enables the precise alignment of student ability training with competition standards.

The fourth strategy is university-enterprise dual-tutor collaboration. The course team has constructed a collaborative guidance mechanism in which campus teachers and enterprise mentors work together. Campus teachers are responsible for theoretical instruction and academic guidance, while enterprise mentors take charge of practical project coaching and the introduction of industry frontiers. The two parties conduct regular joint teaching and research activities to ensure that course content remains closely aligned with actual industrial needs.

The fifth strategy is teacher-student co-creation empowerment. The course opens to students certain sub-tasks extracted from teachers' research projects that are suitable for instructional transformation, such as sentiment analysis and keyword extraction modules. Students participate in frontier research through a project claim process. Instructors incorporate outstanding student outcomes into the course evaluation system and guide students to further apply for software copyrights or utility model patents, thus establishing a complete pathway for transforming achievements from the classroom to the laboratory and then to the market.

3.3. Teaching Content System of Integration of Specialization and Innovation

Based on the "three-stage progressive" model, this course has constructed a "three-in-one" teaching content system.

The professional teaching content focuses on technical foundation building. The course systematically teaches Python syntax basics, data types, functions and object-oriented programming, file operations (JSON/CSV parsing), crawler development (Requests/BeautifulSoup), data visualization (Matplotlib/Seaborn), machine learning (Scikit-learn) and big data development (PySpark), building a complete knowledge system covering basic programming to cutting-edge technology implementation.

The innovation and entrepreneurship teaching content focuses on innovation empowerment. With real enterprise cases and competition real questions as the carrier, elements of innovation and entrepreneurship ability cultivation such as business model design, business plan writing, intellectual property application and roadshow training are integrated. Students are guided to think about commercial value based on technical achievements, achieving the thinking leap from "technical implementation" to "commercial transformation."

The integration content of specialization and innovation focuses on integrated sublimation. Professional knowledge points are deeply coupled with innovation and entrepreneurship elements. For example, in the data analysis module, a sharing economy dataset is introduced and students are required to output a business decision report. In the project development module, the full-process development is completed according to the standards of the "Internet +" competition. In the technical ethics module, combined with the Data Security Law, a data desensitization scheme seminar is carried out to cultivate a responsible awareness of innovation.

4. Teaching Implementation and Effectiveness

4.1. Implementation Path

The "three-stage progressive" model has been implemented in the Python programming course for the Data Science and Big Data Technology major. The course has a total of 32 class hours (including theoretical lectures and experimental practice), and is open to students who have completed prerequisite courses such as C Language Programming and Data Structures.

In the specific implementation, the cognitive stage (about 12 class hours) focuses on classroom lectures and basic experiments, completing the systematic training of Python core syntax and basic programming ability. The ability stage (about 12 class hours) focuses on enterprise case projects, with students completing the full-process development from demand analysis to system implementation in groups. The innovation stage (about 8 class hours) takes the incubation of innovation and entrepreneurship projects as the main line, and students complete business plan writing, project roadshows and achievement declaration.

4.2. Assessment and Evaluation

The course has constructed a dual-track assessment system of "process evaluation (40%) + outcome evaluation (60%)." Process evaluation covers dimensions such as classroom participation, hierarchical task completion, and group collaboration performance. Outcome evaluation includes enterprise project works, competition achievements, business plans, and intellectual property application materials. The diversified evaluation mechanism not only pays attention to students' mastery of professional knowledge, but also focuses on the comprehensive assessment of their innovative practice ability and entrepreneurial literacy.

4.3. Practical Effectiveness

Through teaching practice, the "three-stage progressive" model has achieved remarkable results.

First, students' abilities have been significantly improved. The programming ability pass rate of students reached 100%. In the past three years, the proportion of students participating in Python-related project practice reached 85%, of which 30% won awards in provincial-level or above competitions, and 20% participated in teachers' research projects (such as the National College Students' Innovation and Entrepreneurship Training Program).

Second, competition-course integration has yielded fruitful results. In the past three years, students have been guided to win 1 national-level competition award and multiple provincial-level and above competition awards. Course assignments are benchmarked against competition real questions, and competition achievements feed back into the teaching case library, with the "learning-competition-creation" closed-loop ecology initially taking shape.

Third, university-enterprise collaboration has achieved outstanding results. Relying on the Huawei ICT Academy university-enterprise cooperation platform, enterprise engineers participate in the whole-process guidance of practical projects. In the past three years, 2 software copyright registrations and 2 patent applications have been realized, and 2 student projects have advanced to the provincial and national competitions of the "Internet +" competition.

Fourth, the employment quality continues to improve. 15% of graduates entered related industries for Python development work after graduation, and the employer satisfaction rate of graduates reached 95%, which fully demonstrates the course's effective improvement of students' employment competitiveness.

5. Summary

Integration of specialization and innovation is an important direction of higher education reform in the new era, and it is also the only way to cultivate compound digital talents. Taking the Python programming course as an example, this paper constructs a "three-stage progressive" teaching reform model of integration of specialization and innovation, and realizes the deep coupling of professional education and innovation and entrepreneurship education through the three progressive stages of cognition building, ability deepening and innovation sublimation.

Practice has shown that the "three-stage progressive" model effectively solves the problem of disconnection between professional knowledge and innovation and entrepreneurship in traditional teaching, and while consolidating students' core programming ability, it cultivates their innovative thinking, business literacy and entrepreneurial ability. The core experience of the model can be summarized as: ensuring the basic standards through hierarchical tasks, tempering compound abilities with enterprise cases, driving innovative breakthroughs through competition-course integration, opening up transformation channels through university-enterprise collaboration, and achieving mutual growth through teacher-student co-creation. In the future, the course team will further deepen industry-education integration, expand innovation and entrepreneurship education resources, improve the diversified evaluation mechanism, and continue to promote the iterative optimization of the teaching reform of integration of specialization and innovation. At the same time, we will actively explore the migration and application of the "three-stage progressive" model in other computer science courses, providing more replicable practical paths for cultivating compound digital talents with "professional hard power, innovative creativity and cross-border integration ability."

Acknowledgements

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