A Study on the Evaluation Model of Graduate Students' 0-1 Innovation Capability

Yujie Liu*, Zongmin Li

College of Computer Science and Technology, China University of Petroleum (East China), Qingdao, Shandong 266580, China

*Corresponding author. Email:liuyujie@upc.edu.cn

Abstract. 0-1 innovation is an effective means to enhance a company's technological prowess. The 0-1 innovation ability of graduate students reflects the level of reserve scientific research talents in China. This paper defines the essence of 0-1 innovation capability and analyzes the current assessment models for innovation capability. It proposes an evaluation model that combines outcome-oriented and process-oriented approaches for graduate 0-1 innovation. This model guides graduate students to cultivate their 0-1 innovation awareness from the outset of their course selection, assists mentors in receiving timely feedback on graduate students' 0-1 innovation ability during the training process, and facilitates adjustments to the training process to promote the improvement of graduate students' 0-1 innovation capability.

Keywords: 0-1 innovation, outcome-oriented, process-oriented.

1 The Essence of 0-1 Innovation

In this context, innovation refers specifically to the academic innovation of graduate students, primarily including innovations related to scientific discoveries and technological inventions[1].

0-1 innovation, viewed from the innovation process, signifies innovation from scratch, Its primary characteristic lies in the creation of entirely novel technologies with social value from the ground up. 0-1 innovation represents an effective means to enhance a company's technological prowess.

For graduate students, innovation capability refers to their ability, during research practice guided by their existing theoretical knowledge and practical skills, to optimize problem-solving approaches and produce innovative outcomes with novelty [2,3,4]. 0-1 innovation capability, on the other hand, adds an additional dimension—it requires the capacity to start from zero, encompassing not only innovative thinking but also the practical skills. Cultivating 0-1 innovation capability among graduate students is a long-term training process, necessitating mentors to continually monitor their progress and engage in targeted guide.

To encourage graduate students to actively develop their 0-1 innovation capability, it is essential to introduce an assessment module focused on 0-1 innovation capability

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into the graduate student evaluation process. This would guide and motivate graduate students in their 0-1 innovation capability training.

2 Related works

Currently, most universities employ outcome-oriented approaches to assess innovation, primarily evaluating graduate students' innovation capabilities based on academic papers published in specified journals or granted invention patents [5].

Most research efforts involve extracting factors related to innovation capability to establish an evaluation indicator system. Various evaluating entities assign scores to graduate students based on different indicators[6,7,8]. This approach is advantageous in terms of reference information and comprehensive participation, making the calculation model more scientifically sound. However, due to the involvement of numerous evaluating entities, it is not conducive to real-time evaluations during the educational process. Consequently, this type of innovation capability evaluation model cannot be effectively integrated with the student development process and fails to assist in cultivating graduate students' innovation capabilities.

Notably, none of the evaluation methods in the literature have addressed 0-1 innovation capabilities. Because 0-1 innovation is inherently challenging with a high failure rate, outcome-oriented evaluations are not conducive to improving graduate students' 0-1 innovation capabilities.

The evaluation model designed in this paper primarily assesses the ability to create from scratch. The evaluation indicators are concise, operationally robust, efficient, and capable of providing timely feedback on the real-time status of graduate students' 0-1 innovation capabilities. Moreover, it can be easily and seamlessly integrated with the graduate student development process.

3 Evaluation Algorithm in This Paper

3.1 Objectives of the Proposed Evaluation Model

The evaluation method for assessing graduate students' innovation capabilities serves as the "conductor" of the graduate education process. The choice of evaluation method directly influences the type of graduate students produced. Currently, universities predominantly employ outcome-oriented evaluation methods, where graduate students' innovation capabilities are assessed based on their thesis and research achievements, primarily academic papers and granted patents. Most institutions require graduate students to publish research papers in specific academic journals or obtain patents as conditions for graduation.

However, innovation is a cognitive ability. The generation of innovative outcomes not only requires a certain level of innovation capability but also relies on external environmental conditions conducive to innovation activities. Therefore, possessing innovation capability does not guarantee the immediate creation of innovative technologies and products within a limited timeframe. Consequently, outcome-oriented evaluation

methods may not accurately assess the level of graduate students' innovation capabilities.

Furthermore, relying solely on outcome-oriented evaluation methods can lead to a drawback in graduate student training. When students select research topics for their theses, they tend to choose relatively easier topics to ensure timely graduation. Easier topics entail lower research difficulty, higher success rates, and a greater likelihood of producing innovative outcomes. In the existing evaluation model, this choice by graduate students is understandable because it helps them graduate on time. However, since the research topics are less challenging, the degree of innovation is correspondingly lower. Therefore, this approach has limited effectiveness in fostering the development of 0-1 innovation consciousness and enhancing 0-1 innovation capabilities among graduate students.

Another issue with outcome-oriented evaluation methods is that they only evaluate graduate students' innovation capabilities right before graduation, without providing timely feedback on their innovation capabilities during the training process. Consequently, they do not allow for real-time support in the graduate education process.

In summary, the current outcome-oriented evaluation method for graduate students' innovation capabilities, particularly in the context of fostering 0-1 innovation capabilities, lacks guidance for the training process. It also does not adequately assist in guiding graduate students' innovation capabilities, including 0-1 innovation capability.

Therefore, a graduate student 0-1 innovation capability evaluation model should encompass the following objectives:1) Guiding students in training their 0-1 innovation capabilities.2) Providing real-time feedback on students' 0-1 innovation capabilities during the training process.3) Being highly practical and easily integrated into the graduate education process.

3.2 Evaluation Model

To meet the objectives outlined above for assessing 0-1 innovation capabilities, the evaluation model designed in this paper incorporates both outcome-oriented and process-oriented evaluation modules, effectively combining these two approaches. Additionally, it considers the need to conduct 0-1 innovation capability assessments at any time during the training process, while ensuring that the number of evaluators involved remains limited and relies primarily on the graduate advisor's independent assessment.

Consequently, the 0-1 innovation capability evaluation model in this paper comprises two parallel branches: one focused on outcome-oriented evaluation and the other on process-oriented evaluation, which eventually converge for a comprehensive assessment.

The process-oriented evaluation branch consists of multiple rounds of process evaluation during the research phases. At each stage of the research process, students are required to submit relevant research reports. These reports correspond to various aspects of the research, including research objectives, research plans, feasibility analyses, implementation processes, experimental data, and experimental analyses. Timely submission of reports for each aspect is essential. The graduate advisor evaluates the students' 0-1 innovation capabilities based on these reports, assessing whether the research

progress demonstrates a transition from 0 to 1 and whether the students possess the corresponding technical implementation skills.

Based on the assessment results of graduate students' 0-1 innovation capabilities, advisors can provide guidance during the training process to enhance these capabilities.

The outcome-oriented evaluation branch adopts the common approach used in universities, where students' research achievements, including their thesis, academic papers, and granted patents, are evaluated. In cases where graduate students have not published academic papers or obtained patents, the evaluation is based on the research process documents submitted in the process-oriented evaluation branch. This approach ensures that students who have diligently conducted research and submitted research reports during their studies can have their 0-1 innovation capabilities assessed, even if they have not published academic papers. Such students can meet graduation requirements.

The process-oriented evaluation branch is divided into two parts: 1) Process Evaluation and 2) Graduation Evaluation. Process Evaluation assesses the real-time 0-1 innovation capability of graduate students during their study period. The evaluation results are initially used to guide the training of graduate students' 0-1 innovation capabilities. Graduation Evaluation assesses the 0-1 innovation capabilities of graduate students during their study period and is conducted by an expert panel. The data for evaluation are still the research reports submitted by graduate students during the training process. The final evaluation result of the process-oriented approach is a synthesis of the evaluations by mentors during the training process and the evaluations by the expert panel in the Graduation Evaluation.

In the Process Evaluation, mentors provide scores for each round of research objectives, research content, technical routes, and experimental analysis, denoted as $x_{i1}^{D}, x_{i2}^{D}, x_{i3}^{D}$, and x_{i4}^{D}, respectively, where $i \in [3, \infty)$ represents the round number, 3 represents the minimum required rounds for submission, and D represents the mentor's evaluation. These evaluation results are directly used to assist mentors in guiding the graduate students' 0-1 innovation capabilities during the training process. In the final evaluation, the total score for the best research rounds is used, i.e., using $\max_{i} \sum_{j=1}^{4} x_{ij}^{D}$.

For Graduation Evaluation, each expert in the evaluation panel provides scores for the research reports submitted in each round, denoted as $x_{i1}^{e}, x_{i2}^{e}, x_{i3}^{e}$, and x_{i4}^{e}, where $i \in [3, \infty)$ represents the round number, and $e \in [n, \infty)$ represents the number of participating experts, n is the smallest number, which varies depending on the requirements of each individual institution. Graduation Evaluation uses the highest score given by experts to calculate $\operatorname{avg}_{e} \max_{i} \sum_{j=1}^{4} x_{ij}^{e}$. Therefore, the comprehensive evaluation of the 0-1 innovation capability is $\max_{i} \sum_{j=1}^{4} x_{ij}^{D} + \operatorname{avg}_{e} \max_{i} \sum_{j=1}^{4} x_{ij}^{e}$. This means calculating the evaluation based on the best research rounds from each expert, then adding it to the mentor's evaluation score.

A similar approach is applied to evaluate the 0-1 innovation capability of the outcomes in the result-oriented branch, resulting in the 0-1 innovation capability scores for academic papers X_{r}^{R} and invention patents X_{pa}^{R}. Following the principle of

encouraging 0-1 innovation, the maximum value among all scores is used as the comprehensive score, $\max\{X_r^R, X_{pa}^R, \max_i \sum_{j=1}^4 x_{ij}^D + \operatorname{avg}_e \max_i \sum_{j=1}^4 x_{ij}^e\}$.

Throughout the evaluation process, the data considered include research reports submitted during the training process, published academic papers, and obtained patents. Due to the multiple rounds of revisions and reviews typically associated with publishing academic papers and obtaining patents, their quality is usually higher than that of the research reports submitted during the training process. Therefore, the scoring for academic papers and patents is generally higher than that for research reports. This design streamlines the evaluation process during student graduation. When graduate students have published academic papers or obtained patents, their graduation evaluation can rely solely on these two materials, constituting outcome-oriented evaluation. Only students who have not published academic papers or obtained patents before graduation undergo process-oriented evaluation.

4 Conclusion

This paper investigates the evaluation model for 0-1 innovation capability. The current evaluation methods employed by the majority of universities do not facilitate the selection of research topics with higher potential for cultivating 0-1 innovation capabilities among graduate students when it comes to their thesis or dissertation choices. Furthermore, these methods do not provide feedback within the educational process and fail to assist mentors in guiding the development of graduate students' 0-1 innovation capabilities.

To address these issues, this paper proposes a two-pronged 0-1 innovation capability evaluation model. It constructs evaluation methods from both the educational process and innovation outcomes. This model offers strong practicality, seamless integration with existing evaluation approaches, and the ability to provide real-time assessment of graduate students' 0-1 innovation capabilities. Additionally, it furnishes mentors with the basis to enhance the educational process. Therefore, the evaluation model presented in this paper effectively promotes the cultivation of graduate students' 0-1 innovation capabilities.

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