Improving Postgraduate Students' Scientific Literacy and Research Ability Using Workshops: Evidence from a Chinese University
—Theory, Achievements and Reflection

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Abstract—Postgraduate education bears the dual mission of "high-end talent supply" and "scientific and technological innovation". Whether there is a matching scientific literacy and spirit is one of the important criteria for evaluating the teaching quality of postgraduate students and their universities. With the specific design and implementation of the short-term workshop and the investigation and research, this paper observes and analyzes the performance of the new postgraduate s of the school of business administration of a university in Shandong Province in the six-week workshop, and then discusses how to use this education mode to improve the scientific literacy and research ability of the postgraduate students. The research results show that the workshop, which combines academic lectures and individual and team research exercises, is of practical significance for improving the scientific literacy of postgraduate students. It is also suggested that colleges and universities should refer to the theoretical and practical value of the model and rationally adopt the workshop model to optimize postgraduate education.

Keywords—Postgraduate education, short-term workshop mode, scientific literacy, scientific spirit

I. INTRODUCTION

Postgraduate education, as the highest education system of national education, undertakes the dual missions of "high-end talent supply" and "scientific and technological innovation". It is an important task for China's institutions of higher learning to realize the national scientific research personnel training mission through postgraduate management and training (CPC Central Committee and State Council, 2016). To improve the scientific literacy and academic level of postgraduate s in an all-round way has become an important task of postgraduate education in various universities and a key indicator of the quality of postgraduate training.

From the experience of higher education in western developed countries, short-term workshops for postgraduate students have been widely recognized and applied among many training modes. Learning from the successful experience of western universities, this study held a six-week short-term workshop for newly-enrolled postgraduate students in the School of Business Administration of a provincial university in Shandong, combining various modes of comprehensive academic lectures, off-class research exercises and class presentation (including individual and group projects), to explore the practical possibility of improving the scientific literacy of newly-enrolled postgraduate students through the short-term workshop mode. Based on the level of scientific literacy of newly enrolled postgraduate s, this paper constructs targeted workshop contents and measures the effect of short-term workshop mode on improving postgraduate s' scientific literacy.

II. LITERATURE REVIEW

A. The concept of Scientific Literacy and Its Measurement

Scientific literacy is an important indicator to measure the quality of students in a country. Its sprouting can be traced back to the 1920s, but it was not until the late 1950s that it attracted widespread attention (Laugksch, 1999). Since then, it has become a hot research topic in the field of education in western countries, and there are many different opinions on what is scientific literacy and the definition and connotation of the concept. For example, the OECD believes that scientific literacy is the ability to use scientific knowledge to identify problems and make evidence-based conclusions in order to understand and make decisions about the natural world and changes in the natural world through human activities. Scientific literacy means training people to have a basic understanding of nature, to understand scientific goals and limitations, and to be able to understand important scientific ideas (Jenkins, 1994). It is generally recognized internationally that professor miller, vice president of the Chicago academy of
sciences in the United States, proposed the three interrelated components of scientific knowledge, scientific methods and the role of science in society. However, Laugksch (2000) proposed that the measurement of scientific literacy should be determined according to different groups of people, and there should not be only one concept and its connotation. In other words, for ordinary people and professional postgraduate students, the connotation of scientific literacy is very different.

Before 2001, "ability" and "quality" were commonly used words in related researches in the field of education in our country. Subsequently, the word "literacy" was used more frequently in relevant national documents, replacing basic knowledge and basic abilities and becoming a new core training goal. However, according to different specialties and research fields, some refer to the literacy in the process of scientific research as "scientific literacy" and others as "research accomplishment". The definition and composition of the two are carefully studied. Apart from their different names, the contents of the two have not yet seen obvious differences. Therefore, this paper examines the opinions of literature on scientific accomplishment and scientific accomplishment in different years. Zhang Nianuo (2008) held that the current situation of scientific research accomplishment should be discussed from three aspects: scientific research consciousness, scientific research theory and scientific research method. Chai Xiaoli (2008) proposed that "scientific research literacy mainly refers to scientific research knowledge, scientific research skills and scientific research spirit." Zhan Meiying (2008) divided scientific research accomplishment into: "scientific research consciousness, scientific research knowledge, scientific research ability and scientific research spirit. Li Changping (2009) focused on the cultivation of students' scientific research literacy in three aspects: scientific research theory literacy, scientific research ability literacy and scientific research ethics literacy. Li Shibin (2016) believed that postgraduate students' scientific literacy includes four aspects: the cultivation of scientific ethics, the cultivation of scientific research interests, the cultivation of basic scientific research methods and the summary of scientific research results. On the basis of OECD definition, Li Jing (2017) concluded that the scientific research accomplishment of postgraduate s mainly includes: scientific spirit of pursuing truth, problem consciousness, ability to process and screen information, ability to solve problems, etc.

Although scholars have different opinions on the scientific literacy of postgraduate s, based on the common cognition of various scholars on the scientific literacy and scientific research literacy of postgraduate s and the current practical problems of scientific literacy of management postgraduate s, this paper holds that the scientific literacy of postgraduate s mainly includes the following three specific aspects, namely, scientific literacy, scientific theory and scientific method. The concrete manifestation of scientific quality is daring to question, pursuing truth, perseverance and not giving up lightly. According to the motivation theory of American educational psychologist AuSubel, the motivation of learning comes from internal drive to drive learning. Among them, learners' thirst for knowledge and knowledge are the key to internal drive. In the process of pursuing truth, the tempering of will and the demand for flexibility are essential. Some scholars use "scientific consciousness" and "scientific spirit" to embody them. In this research, they are collectively referred to as "scientific quality". Scientific theory is mainly embodied in the ability to query documents, the level of professional theoretical knowledge and the ability to refine and improve research problems. Other documents are called "scientific knowledge". Quantitative change leads to qualitative change. Only when the general scientific and cultural knowledge and professional knowledge mastered by postgraduate s reach a certain level of accumulation can various kinds of knowledge be linked, new ideas and concepts be formed, and thinking be developed. Scientific methods are mainly embodied in the mastery of methodology and methods, the ability to write papers and the ability to study independently. That is, the methodology knowledge and application ability in the knowledge structure of postgraduate students. For any scientific activity, the choice and use of methods have a vital influence on the research results. Scientific research requires postgraduate students to be able to express new ideas, new viewpoints, new ideas, etc. that have been studied with great concentration in theory through papers, works and other forms under the verification of applicable methods, thus publicizing research results and promoting academic exchanges. In the whole research process, the self-study ability is also one of the necessary factors for postgraduate students' accomplishment, due to the limitation of postgraduate students' education mode, tutor knowledge and teaching resources in colleges and universities. In other documents, some scholars call them "scientific ability", "scientific methods" and "scientific skills", which are collectively referred to as "scientific methods".

B. Research on Postgraduate Workshop

Workshop is an important part of postgraduate training in western universities. Students are usually required to attend various workshops, including research methods, software use, literature search, employment guidance and academic writing. Wisker, et al.(2007) pointed out that the effectiveness of the workshop is not only to strengthen the participants' specific skills in the short term, but also to trigger more cooperation in the future by strengthening the interaction of the participants' groups during the workshop, thus bringing long-term benefits. Lydon and King (2009) stressed that workshops that can bring long-term gains need to meet a number of important conditions, such as refined content, good structure and strong interaction, and pointed out that teachers need rich experience and sufficient preparation. These requirements are in line with the concept of taking postgraduate s as the foundation, emphasizing the enhancement of postgraduate s' autonomy, reducing indoctrination, and considering practicability to a certain extent, reducing the possibility of participants' fatigue and accumulating boredom. This kind of teaching mode is quite common in western postgraduate education. Through this attempt, we will investigate the degree of influence on the improvement of domestic postgraduate scientific literacy and research ability.
III.  RESEARCH AND DESIGN

A. Research Object

This paper focuses on the newly enrolled postgraduate students of 2017 (29) and 2018 (31) in Shandong University of Finance and Economics, Institute of Business Administration. Taking freshmen as the research object is to effectively master their knowledge of scientific literacy before any postgraduate training and their cognitive changes after training. Through comparative study, we can find an effective way to improve their scientific literacy.

B. Research Purposes

To understand the understanding of academic research and the level of scientific literacy of postgraduate students in the school of business administration at the beginning of their admission, and to master the role of this educational mode in improving their scientific literacy and related capabilities by adopting a short-term workshop of scientific literacy lasting for 6 weeks and 8 hours per week.

C. Research Time and Process

The study lasted for 2 years. Through a six-week, one day per week (8 hours) curriculum arrangement at the beginning of the fall semester of 2017 and 2018, a phased analysis was carried out on the scientific literacy-related cognition and research ability of the two postgraduate students enrolled in Grade 17 and Grade 18 before, during and after the workshop. Finally, the two analysis results are integrated and sorted out to obtain the final research results. Among them, before and after the start of the workshop, students' self-assessment is mainly conducted through questionnaire survey, and the content and form of the workshop are specifically designed according to the self-assessment of students before the start. In the process of implementation, dynamic analysis is carried out by means of random interviews and feedback of opinions in the course, as well as appropriate adjustment of teaching contents and methods in workshops. The following research results are the results of the integration of the two workshops without distinction. The reasons is that through investigation, the participants’ self-evaluation before and after scientific literacy and other aspects are not significantly different due to grade differences.

IV.  RESEARCH RESULTS AND ANALYSIS

A. Self-evaluation Results and Analysis of Students before Training

In order to further refine the content of the workshop, this study conducted an electronic questionnaire survey on the postgraduate students of the School of Business Administration before the workshop began. The contents of the survey mainly include the freshmen's own interest in the research, the description of their primary goals and motives, and the analysis of their personality (pursuit of truth; Not from the standpoint of utilitarianism; Not superstitious about authority; No preset position; Doubt everything; Resilience and patience, etc.), theory (degree of mastery of enterprise management ideas; The ability to consult papers; The ability to ask questions, etc.) and methods (understand the number of scientific research methods and tools for enterprise management; Training time of research methods per academic year; Self-study research methods and application time, etc.) to evaluate their scientific literacy. Timely self-evaluation is of great significance to postgraduate students. Through evaluation and reflection, one can recognize one's own strengths and weaknesses, carry out targeted improvement, and realize the purpose of self-education.

TABLE I.  SELF-ASSESSMENT RESULTS OF POSTGRADUATE'S SCIENTIFIC LITERACY

| Scientific Literacy | Specific Performance                                | Likert Scale * | Average Value |
|---------------------|----------------------------------------------------|----------------|---------------|
|                     |                                                    | 1 2 3 4 5       |               |
| Quality             | Dare to question and pursue truth                  | 0 2 29 23 6     | 3.55          |
|                     | Perseverance, not giving up lightly                | 2 2 12 32 12    | 3.83          |
|                     |                                                    |                |               |
| Theory              | Ability to search documents                        | 6 27 17 10 0   | 2.52          |
|                     | Professional theoretical knowledge level           | 6 31 13 10 0   | 2.45          |
|                     | Refine and Improve the Ability to Study Problems   | 2 31 21 4 2    | 2.55          |
| Method              | The mastery of methodology and methods             | 15 31 8 6 0    | 2.08          |
|                     | Paper writing ability                              | 4 39 13 4 0    | 2.28          |
|                     | Self-study ability                                 | 4 16 21 19 0   | 2.92          |

* The score is 5 as the highest (very satisfied/approved) and 1 as the lowest (very dissatisfied/disapproved)

As shown in Table I, the results of the initial self-evaluation survey highlighted the fact that postgraduate students have more theoretical and methodological problems and lower self-confidence. The self-evaluation of newly enrolled postgraduates on literature search and analysis, mastery of
professional knowledge, research topic setting, and selection of appropriate research paradigm and method is lower than (or close to) the median value, which indicates the inadequacy of their scientific literacy. The content of the workshop should be arranged according to these deficiencies, so as to achieve improvement.

At the same time, the questionnaire also contains some open questions. The postgraduate students participating in the study described their own research motivation, the importance of studying different factors in life and the support they hope to receive. The results show that the participants’ own research field is uncertain and their research motivation is vague. They are very much looking forward to more detailed guidance from their tutors and more detailed guidance in establishing research propositions and methods 12. On the positive side, this phenomenon proves that the academic level and guiding methods of tutors are of great significance to postgraduate students, especially freshmen, lack autonomy and rely heavily on tutors. Most of the postgraduate students in western universities continue to engage in research, so the western universities' view on the tutor style follows the principle of encouraging the postgraduate students to promote knowledge construction and self-development, which is higher than the principle of giving directions (Vereijken et al., 2017), so as to avoid the situation that postgraduate students are low in innovation spirit, excessively dependent on tutors and passively accepted. However, regarding the future prospects in the questionnaire, postgraduate students participating in the survey generally pointed out that successful graduation and job opportunities are the most important learning objectives. This practical attitude is very common in the current values of postgraduate students and shows a trend of secularization (Xie Maohua, 2001). Such inappropriate values lead to low autonomy of postgraduate students and exhaustion of innovation vitality, which are detrimental to postgraduate students themselves, universities and society (Qian Peizhong, 2011).

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### B. Construction of Workshop Mode

This study designed a six-week workshop plan, covering the perplexed problems of postgraduate students in the lectures, and arranging individual and group exercises to test the short-term results. The workshop is held in the morning and afternoon on one day of the week. The morning lectures are mainly aimed at strengthening the theoretical and methodological literacy of postgraduate students. The content combines classic literature analysis and teacher experience sharing, as well as interactive questions and answers. The overall time is 90 to 120 minutes. In the afternoon, the content is mainly interactive exercises. Teachers and participants conduct one-to-one or one-to-many discussions to test participants’ absorption and mastery and to guide individual/group exercises. The last week of the workshop adopted the model of a simulated academic conference and conducted research plan reports and reviews in small groups. It also invited teachers and senior students from the School of Business Administration to form a judging panel to make supplementary remarks on the reports and reviews. This model is intended to create a simulated professional academic conference environment, to mobilize the enthusiasm of participants, to enhance the academic life experience, and to construct a triangulation peer assessment model of researcher-report-classmate mutual evaluation-mentor general evaluation to achieve the purpose of strengthening the academic value of workshop practice (Topping et al., 2000). Details of the workshop are shown in Table II.

| Table II. Content Design of Workshop |
|--------------------------------------|
| **Period** | **Lecture Content** | **Students' Interactive Exercises** |
| First Week | Brief Introduction of Overseas Postgraduate Training Mode | Personal Introduction, Research Purpose and Prospect |
| Second Week | Significance and Construction Techniques of Literature Review | Select Core Documents |
| Third Week | Research Methodology | Core Literature Analysis Display Report (Individual) |
| Fourth Week | Application of Common Research Methods | Group Study Plan to Set Questions |
| Fifth Week | Analysis and Communication of Research Contribution | Exchange and Mutual Evaluation of Group Research Plans |
| Sixth Week | Report on Workshop Results: Presentation and Comments on Group Research Plans (Academic Conference Simulation) | |

- **Short-term Results of Workshop-Participants' Feedback and Researchers' Observation, Analysis and Discussion**

After the workshop, the postgraduate students of the two workshops participated in the second questionnaire survey respectively. The second survey involved participants' evaluation of the entire workshop, self-evaluation of their scientific literacy improvement and feedback on their preferences in different links of the workshop.

In the survey on the popularity of each link in the workshop, the feedback from two postgraduate students showed that they had a high degree of approval for the introduction of literature review skills in the workshop. In 2017, 23.81% of postgraduate students rated the introduction of literature review skills as their favorite link, and in 2018, 25.81% of students rated it as their favorite link. It can be seen that for newly enrolled
postgraduate students, it is just a matter of time before they learn by themselves through literature review and analysis. At the same time, the students think that the most meaningful links are literature review skills lectures and group research plan reports and comments (academic conference simulation), with data of 19.05% (2017 grade) and 29.03% (2018 grade) respectively. In allowing students to freely choose topics for research ideas and frame presentations, each group and mentor evaluates the value of topics, theoretical research, research methods, research contributions, and advantages and disadvantages of research construction. Students’ ability to conduct normative research is improved through thinking-practice-reflection. Secondly, the personal experience shared by teachers and the importance of basic literacy training for university postgraduate students are expounded. On the contrary, the contents that favor method literacy, including methodology foundation and research contribution, are relatively less popular. Methodology and philosophy have always been the contents that students think are boring and difficult to understand.

Researchers believe that the feedback results at the later stage accurately reflect the psychological state of the postgraduate students and the practical problems they are facing at the early stage of the study. In view of the fact that the main task of postgraduate students in the first year of admission is usually related to literature reading and literature review writing, targeted content is easy to be paid attention to. Timmerman et al. (2013) emphasized that master of core documents in related fields is a necessary condition for strengthening other research capabilities. In the design of this study, the teacher asked the participants to select a very prominent top-level document in the relevant field, to make a multi-level in-depth analysis, and to elaborate on the outstanding contributions and shortcomings of the document. This approach can not only enable postgraduate students to contact the core documents as soon as possible and improve their theoretical level, but also stimulate the quality of students and encourage postgraduate students to question the scientific research results published in top-level documents and dare to express their views. This kind of exercise integrates the cultivation of postgraduate’s theoretical foundation and personal expression ability.

The students showed very high support for the group research plan report and comment activities conducted in the academic conference simulation environment. The "student conference" is a highly recognized teaching pedagogy that creates a formal environment in which postgraduate students gain satisfaction and pride by reporting authentic research results, practicing writing and oral expression skills, and accumulating research life experiences (Larkin, 2014). In this workshop, the researchers also observed that the postgraduate students showed very high enthusiasm in this link, the report of the group research plan showed rich diversity and innovative spirit, and the group mutual evaluation activity also showed high investment and better completion (see Table III). The amount of work done and the level shown by the postgraduate students in the limited time soon after admission are worthy of recognition. The workshop has played a role in expanding the vision of the postgraduate students, encouraging the spirit of innovation and promoting the spirit of scientific research team cooperation.

### TABLE III. 2017/2018 TOP THREE LISTS OF STUDENTS' FAVORITE LINKS IN WORKSHOP

| Problem                                                                 | 2017 | 2018 | 2017 | 2018 | 2017 | 2018 |
|------------------------------------------------------------------------|------|------|------|------|------|------|
| A Brief Introduction to Basic Literacy Training for Postgraduate s in Western Universities | 19.05% | 12.90% | 9.52% | 12.90% | 9.52% | 3.23% |
| Introduction of Literature Review Skills                              | 23.81% | 25.81% | 33.33% | 9.68% | 19.05% | 9.68% |
| Introduction to Research Methodology and Philosophical Basis           | 9.52% | 6.45% | 9.52% | 12.90% | 14.29% | 19.35% |
| Discussion on Research Methods                                         | 0.00% | 3.23% | 9.52% | 16.13% | 9.52% | 16.13% |
| Discussion on Research Contribution                                   | 4.76% | 0.00% | 4.76% | 12.90% | 4.76% | 9.68% |
| Group research plan reporting exercise and comment exercise            | 19.05% | 29.03% | 0.00% | 16.13% | 9.52% | 16.13% |
| Personal Literature Review Report Exercise                             | 0.00% | 12.90% | 14.29% | 19.35% | 28.57% | 16.13% |
| In the lecture, Mr. Huang interspersed his personal feelings and experiences with others | 23.81% | 9.68% | 19.05% | 0.00% | 4.76% | 9.68% |
The students are very interested in the personal experiences shared by the teachers (including studying the experiences, experiences and experiences in various stages of life, etc.), and feedback of these experiences in the later investigation will be of some inspiration and encouragement to them. Based on this, the researcher suggests adopting the role model in the postgraduate workshop to create a close communication and interaction environment for the postgraduate students, senior students and scholars. This model is conducive to improving the postgraduate students’ environment and academic scope, helping freshmen to reduce their anxiety at the beginning of the study by understanding previous experiences and experiences, and reducing the work pressure of tutors in managing postgraduate students' mental health.

Table IV shows the self-evaluation of students' improvement in their personal scientific literacy after two workshops. It can be seen that 23.81% and 27.59% of the postgraduate students in 2017 and 2018 respectively believe that workshops have improved their ability to analyze a document in depth, and learning to analyze documents mathematically is the foundation of academic research. At the same time, the cultivation of scientific literacy requires "standing on the shoulders of giants". Through the analysis of documents, the academic thought research system of postgraduate students can be effectively established. Through the understanding of different research methods and ideas, research paradigms and philosophical foundations, postgraduate students can understand research tools and application environment, thus enhancing the standardization of academic research. On the basis of knowledge, through group presentations, workshops play an important role in the cultivation of team cooperation spirit in the research, breaking the situation of working alone, improving the research efficiency, and allowing newly enrolled postgraduate s to have a deeper understanding of the qualities that need to be cultivated in the future postgraduate s’ life, and defining the future direction and tasks. According to the survey, more than 80% of the participants in the two workshops said that the deficiencies they felt in the self-evaluation of research literacy, including academic literacy, research spirit, persistent quality, questioning scientific spirit, self-learning ability and time arrangement, were improved, and they hoped to have more opportunities to participate in similar activities in the future.

TABLE IV. SUMMARY OF STUDENTS’ PERSONAL VIEWS ON IMPROVEMENT OF SCIENTIFIC LITERACY FROM 2017 TO 2018

| Problem                                                                 | 2017      | 2018      |
|------------------------------------------------------------------------|-----------|-----------|
| 1 Ability to analyze a document in depth                               | 23.81%    | 27.59%    |
| 2 Understanding of research Paradigm and Philosophical Basis          | 9.52%     | 6.90%     |
| 3 Understanding of different research methods and ideas               | 23.81%    | 10.34%    |
| 4 Self-confidence in doing a research project by oneself              | 9.52%     | 13.79%    |
| 5 Self-confidence in the degree of recognition of one's contribution to research projects | 4.76%     | 0.00%     |
| 6 Have a deeper understanding of the qualities that postgraduate students need to cultivate in their future life | 14.29%    | 17.24%    |
| 7 Team Spirit in research                                            | 14.29%    | 24.14%    |
| 8 Others (please indicate)                                           | 0.00%     | 0.00%     |

V. CONCLUSION

As an exploratory study, this paper examines the practical effect of a workshop model on improving the scientific literacy and research ability of postgraduate students. By analyzing the theoretical basis of the concept of scientific literacy and combining with international advanced experience, it is found that short-term workshops can be promoted as a model in colleges and universities to strengthen the scientific literacy of postgraduate s, create an educational environment conducive to the development of postgraduate s, and realize the management purpose of combining standardization and personalization in the initial stage of postgraduate s. This model can form a good complement with the postgraduate's own course selection study and the relationship between tutors and students. To a certain extent, it integrates the scientific literacy that the postgraduate needs to cultivate. It can reach a consensus with the postgraduate on the importance of scientific literacy from three aspects of quality, theory and method. It can encourage the participating postgraduate to continue to develop their own scientific literacy in the future research life and has achieved the long-term benefit.

Through workshop training, the skills of postgraduate students in academic theories and methods have been effectively improved, and the low self-confidence of students has been improved. In addition to the workshop's own model, the links that benefit more from participants' feedback can be further developed into required courses or elective courses to be added to the postgraduate study planning. University management can consider combining
long-term study of required courses with short-term reinforcement of workshops to enable postgraduate students to have a deeper grasp of knowledge and skills that can significantly improve their scientific literacy and research ability. The workshop itself can play an exploratory role in getting closer to the life of postgraduate students, understanding the real needs of postgraduate students and the problems they are facing, so as to facilitate tutors and managers to carry out scientific research and life guidance on the problems and further realize the goal of concretizing the management content of postgraduates.

Since this study is in the exploratory and experimental stage, the available data are not sufficient to provide empirical evidence for the role of workshop mode in improving the scientific literacy and research ability of postgraduate students. In the future, researchers hope to accumulate data and make more perfect research and analysis on the efficacy of workshop mode by observing the postgraduate students participating in workshop for a long time and expanding the number and scope of samples.

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