



A Study on the Mechanism of Tutor Guidance on Scientific Research Ability of Undergraduates in Application-oriented Universities—Based on the Mediating Effect of Research Efficacy

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Abstract

Scientific research training is a key path to cultivating the practical innovation ability of undergraduates in application-oriented universities, and tutor guidance is its core practice form. Based on the theory of situated learning, this study investigated 723 undergraduates from 3 application-oriented universities. The results show that students who received tutor guidance significantly outperformed those who did not in scientific research ability indicators. After controlling variables such as gender, grade, major, and academic performance, tutor guidance had a positive impact on the scientific research ability of undergraduates in application-oriented universities, among which the three dimensions of guidance frequency, guidance method, and guidance content all showed significant positive effects. Research efficacy played a mediating role in the relationship between tutor guidance and scientific research ability. Further analysis showed that factors such as students' individual characteristics (such as research motivation and professional foundation), universities' scientific research environment (such as laboratory resources and school-enterprise cooperation platforms), and institutional support (such as scientific research incentive policies) also significantly moderated or mediated this influence path. The research results have theoretical reference and practical guidance value for application-oriented universities to optimize the tutor guidance system and cultivate practical innovative talents.

Keywords

Tutor guidance; Scientific research ability; Research efficacy; Application-oriented talent training; Influencing factors

1. Introduction

As higher education shifts from scale expansion to quality enhancement, application-oriented undergraduate universities—serving as the primary arena for cultivating practical and innovative talents—face significant challenges in developing undergraduates' research capabilities. Compared with research universities, these universities commonly suffer from limited research resources and underdeveloped academic training systems, leading to low student engagement in research and insufficient innovative capacity (Li, 2022). Under this background, mentor guidance emerges as a critical pathway to bridge resource gaps: through personalized research training, methodology

instruction, and academic value cultivation, mentors can effectively activate students' research potential.

However, existing studies predominantly focus on the direct impact of mentor guidance while paying inadequate attention to its intrinsic mechanisms. Research self-efficacy—an individual's belief system regarding their own research abilities—may constitute a core mediating variable. Mentors enhance students' confidence in core competencies such as experimental design and data analysis, thereby strengthening their research persistence and innovation (Wang, 2023). This “mentor guidance → self-efficacy → research capability” mediating pathway has great significance for optimizing mentor guidance design in application-oriented institutions.

Some researchers, starting from the perspective of supervisory mechanisms, argue that the implementation of an undergraduate tutorial system helps stimulate students' enthusiasm and initiative, promotes teacher-student interaction, and enhances teaching quality (Zhang, 2022). Meanwhile, through surveys of local universities, they analyze the implementation status of the undergraduate tutorial system, providing empirical support for optimizing its implementation strategies (Luo, 2022). The study examines the implementation status of the undergraduate tutorial system via an empirical investigation conducted across local universities (Liu, 2023). However, the research on the influence of tutor guidance on individual scientific research ability is relatively limited, especially the lack of systematic empirical analysis on the influence mechanism of tutor guidance. Based on this, this study focuses on deeply exploring the path of tutor guidance on their scientific research ability, so as to provide an empirical basis for optimizing the scientific research training system for undergraduates in application-oriented universities.

2. Literature Review and Research Hypotheses

2.1 Connotation of Scientific Research Ability of Undergraduates in Application-oriented Universities

At present, there is no unified standard in the academic circle for the understanding of the scientific research ability of undergraduates in application-oriented universities. Some researchers define it as operational capabilities such as data collection, experimental design, data processing, and achievement transformation, as well as comprehensive qualities such as problem-solving and team collaboration from the perspective of the scientific research practice process. This study tends to specifically define scientific research ability as literature retrieval, problem identification, experimental operation, data analysis, and achievement application from the practical process of scientific research training for undergraduates in application-oriented universities (see Table 1) (Wang, 2008).

Table 1. Dimension of Scientific Research Ability

| Dimension of Scientific Research Ability | Specific Indicators | Application Scenario Examples |
|--|---|---|
| Literature Retrieval Ability | Chinese and foreign literature retrieval, literature review writing | Writing a technical status analysis report of an enterprise |
| Problem Identification Ability | Extraction of production practice problems, transformation of research problems | Diagnosis of efficiency bottlenecks in factory assembly lines |
| Experimental Operation Ability | Use of instruments and equipment, experimental scheme design | New material performance testing experiment |
| Data Analysis Ability | Application of statistical software, data visualization presentation | Market research data mining |
| Achievement Application Ability | Patent writing, technical scheme implementation | Application for utility model patents |

2.2 Dimensions of Tutor Guidance

Tutor guidance refers to the process in which tutors help students improve their scientific research ability through knowledge transmission, method training, and scientific research practice guidance. According to the core elements of guidance practice, tutor guidance can be divided into three dimensions:

Guidance frequency: The communication frequency between tutors and students in the scientific research process, reflecting the sustainability of guidance.

Guidance method: Including diversified guidance forms such as face-to-face guidance, online feedback, and team discussion.

Guidance content: Covering specific guidance points such as research method transmission, experimental design optimization, data interpretation, and achievement writing.

2.3 Relationship between Tutor Guidance and Scientific Research Ability

Existing studies have shown that systematic tutor guidance can effectively improve the scientific research practice ability of undergraduates. Tutors' professional knowledge reserve, scientific research experience accumulation, and guidance strategy selection have an important impact on the shaping of students' scientific research ability. The increase in guidance frequency helps students solve research puzzles in a timely manner. Diversified guidance methods can meet the learning needs of different students, and targeted guidance content directly promotes the completion of scientific research tasks. The situated learning theory further points out that tutors, as guides in the "cognitive apprenticeship", provide scaffolding guidance to help students gradually master scientific research skills. Based on this, this study puts forward the following hypotheses:

H1: Tutor guidance has a significant positive impact on the scientific research ability of undergraduates in application-oriented universities.

H1a: Guidance frequency has a significant positive impact on the scientific research ability of undergraduates in application-oriented universities.

H1b: Guidance method has a significant positive impact on the scientific research ability of undergraduates in application-oriented universities.

H1c: Guidance content has a significant positive impact on the scientific research ability of undergraduates in application-oriented universities.

2.4 Relationship between Tutor Guidance and Research Efficacy

Research efficacy originates from Bandura's self-efficacy theory, which refers to an individual's belief in their ability to complete scientific research tasks and achieve research goals. In the context of applied scientific research, research efficacy reflects the confidence of undergraduates in using professional knowledge to solve practical problems and complete scientific research projects (Bandura, 1977). Empirical studies have found that the quality of tutor guidance significantly affects students' research efficacy, among which personalized guidance, timely feedback, and resource support have the most prominent impacts. The technical support and psychological encouragement provided by tutor guidance help cultivate students' scientific research confidence (Phillips & Russell, 1994). Thus, the following is proposed:

H2: Tutor guidance has a significant positive impact on the research efficacy of undergraduates in application-oriented universities.

H2a: Guidance frequency has a significant positive impact on the research efficacy of undergraduates in application-oriented universities.

H2b: Guidance method has a significant positive impact on the research efficacy of undergraduates in application-oriented universities.

H2c: Guidance content has a significant positive impact on the research efficacy of undergraduates in application-oriented universities.

2.5 Relationship between Research Efficacy and Scientific Research Ability

Regarding the role of research efficacy, some scholars have pointed out that it is an important motivation for scientific research behavior, affecting an individual's research investment and achievement output. Empirical studies

have shown that research efficacy significantly affects the scientific research practice behavior of undergraduates, and the higher the level, the more significant the improvement of scientific research ability (Gao, 2016). In the context of tutor guidance, research efficacy reflects the internal motivation of students to participate in scientific research. Positive research efficacy helps promote students to take the initiative to explore, overcome difficulties, and then improve their scientific research ability. Based on this:

H3: Research efficacy has a significant positive impact on the scientific research ability of undergraduates in application-oriented universities.

2.6 Mediating Role of Research Efficacy

Existing studies have shown that self-efficacy plays a mediating role in the relationship between the learning environment and ability development. In the context of scientific research, tutor guidance affects students' research efficacy and then acts on the formation of scientific research ability. Specifically, the effective guidance provided by tutors can enhance students' scientific research confidence, and students with high research efficacy are more inclined to take the initiative to undertake scientific research tasks and try innovative methods, thus promoting the improvement of scientific research ability. Therefore, it is proposed:

H4: Research efficacy plays a positive mediating role between tutor guidance and scientific research ability.

H4a: Research efficacy plays a positive mediating role between guidance frequency and scientific research ability.

H4b: Research efficacy plays a positive mediating role between guidance method and scientific research ability.

H4c: Research efficacy plays a positive mediating role between guidance content and scientific research ability.

2.7 Analysis of Multidimensional Influencing Factors of Scientific Research Ability

The cultivation of scientific research ability of undergraduates in application-oriented universities is a multi-dimensional and systematic process, and its influencing factors can be analyzed from five levels: student individual, tutor guidance, university environment, institutional support, and social environment.

2.7.1 Factors of Student Individual: Internal Foundation for Scientific Research Ability Development

Research motivation and interest: Intrinsic motivation (such as the desire to explore the unknown and solve problems) can drive students to continuously invest in scientific research more than extrinsic motivation (such as awards and evaluations, postgraduate entrance examination bonus points). A survey shows that the completion rate of scientific research projects of students whose professional course scores rank in the top 30% is 42% higher than that of the latter 30% ($t=5.721$, $P<0.001$).

Professional basic knowledge and practical skills: A solid professional foundation is the cornerstone of scientific research ability, and the practical skills (such as instrument use and data analysis software operation) of undergraduates in application-oriented universities directly affect the completion quality of scientific research tasks.

Critical thinking and problem-solving ability: Scientific research is essentially a process of discovering and solving problems, and students with critical thinking are more likely to form innovative points in scientific research.

Research efficacy and stress resistance: Students with high research efficacy are more willing to challenge complex projects and are more likely to adjust their mentality when failing ($r=0.603$, $P<0.001$) (Yang, 2017).

2.7.2 Factors of Tutor Guidance: Direct Driving Force for Scientific Research Ability Improvement

Guidance frequency and sustainability: The output of scientific research achievements of students who receive more than 2 face-to-face guidance sessions per week is 58% higher than that of students who receive 1 guidance session per month ($F=12.364$, $P<0.001$).

Appropriateness of guidance methods: The combination of hierarchical guidance (focus on method teaching for novices, focus on innovative guidance for skilled students) and diversified forms (online + offline + enterprise site) is more in line with the needs of applied scientific research.

Application orientation of guidance content: If tutors combine scientific research guidance with industrial needs (such as enterprise production data mining), the speed of students' scientific research ability improvement is significantly accelerated.

2.7.3 Factors of University Environment: Support Platform for Scientific Research Ability Cultivation

Scientific research hardware resources: The scientific research ability test scores of students in universities with

industry-oriented laboratories (such as intelligent manufacturing laboratories) are 31% higher than those in universities with scarce resources ($t=4.289$, $P<0.001$).

School-enterprise cooperation bases: The proportion of students in universities that build scientific research practice bases with enterprises participating in real scientific research topics reaches 67%, which is significantly higher than that in universities without bases ($\chi^2=28.741$, $P<0.001$).

2.7.4 Factors of System Support: Long-Term Guarantee for Scientific Research Ability Cultivation

Scientific research incentive policies: The participation rate of students in scientific research in universities that incorporate scientific research achievements into the credit system is 49% higher than that in universities that do not ($F=8.627$, $P<0.001$).

Assessment and evaluation mechanism: A practice-oriented evaluation system (such as the score of enterprise tutors accounting for 30%) can better promote the development of students' scientific research ability.

2.7.5 Factors of Social Environment: External Thrust for Scientific Research Ability Transformation

Industry demand and enterprise participation: The transformation rate of scientific research achievements of students in universities closely connected with local industrial needs reaches 38%, which is higher than that in disconnected universities ($\chi^2=19.536$, $P<0.001$).

Policy and financial support: Students who receive government special subsidies for applied scientific research invest 2.3 more hours per week in scientific research than those who do not ($t=3.815$, $P<0.001$).

3. Research Design

3.1 Scale Development

This study uses a questionnaire survey method. The questionnaire includes five parts: background information, tutor guidance situation, scientific research ability self-evaluation, research efficacy measurement, and multi-dimensional influence factor survey. Among them:

The tutor guidance dimension refers to Smith and other scholars' guidance behavior scale, which is adjusted to three sub-dimensions: guidance frequency, guidance method, and guidance content, with a total of 15 questions.

The scientific research ability evaluation index refers to Kardash's research, and the "achievement application ability" dimension is added in combination with application-oriented characteristics, with a total of 20 questions (Kardash, 2000).

The research efficacy measurement is adapted from Bieschke's scientific research self-efficacy scale, with a total of 10 questions.

The influence factor part includes student individual characteristics (research motivation, professional foundation, etc.), university environment (laboratory resources, school-enterprise cooperation, etc.), institutional support (incentive policies, assessment mechanisms, etc.), and social environment (industry demand, policy funds, etc.), with a total of 30 questions (Bieschke, 1996).

The scale uses a Likert five-point scoring method, where "1" means "highly inconsistent" and "5" means "highly consistent".

3.2 Data Collection

Based on the principles of representation and feasibility, three application-oriented universities, A, B, and C, were selected as sample universities. All three universities have carried out the undergraduate tutor system and paid attention to scientific research practice training. Before the formal investigation, a pre-research and cognitive interview were carried out, and the questionnaire was revised according to the feedback. Through stratified sampling combined with university recommendation, the questionnaire was distributed online using the Wenjuanxing platform. A total of 801 questionnaires were recovered, and after excluding invalid questionnaires such as those with too short filling time and logical contradictions, 723 valid questionnaires were retained, with an effective recovery rate of 90.3%. The sample composition is as follows:

Gender: 412 males (57.0%), 311 females (43.0%);

Grade: 189 freshmen (26.1%), 235 sophomores (32.5%), 198 juniors (27.4%), 101 seniors (14.0%);

Major: 286 engineering students (39.6%), 227 science students (31.4%), 210 humanities and social sciences

students (29%);

Research motivation: 387 people (53.5%) dominated by intrinsic motivation (such as “solving practical problems”), 336 people (46.5%) dominated by extrinsic motivation (such as “postgraduate entrance examination bonus points”);

Tutor guidance experience: 452 people (62.5%) have received guidance, 271 people (37.5%) have not.

3.3 Reliability and Validity Test

Reliability analysis was carried out using SPSS 26.0, and the results showed that the overall Cronbach's α coefficient of the questionnaire was 0.958, the reliability coefficients of each sub-scale were all greater than 0.9, and the α coefficients of each dimension were all greater than 0.85, indicating that the questionnaire had good internal consistency (see Table 2).

Table 2. Analysis Result of Good Internal Consistency

| Scale Dimension | Number of Questions | Cronbach's α |
|-----------------------------|---------------------|---------------------|
| Tutor Guidance | 15 | 0.927 |
| Guidance Frequency | 5 | 0.885 |
| Guidance Method | 5 | 0.902 |
| Guidance Content | 5 | 0.891 |
| Scientific Research Ability | 20 | 0.946 |
| Literature Retrieval | 4 | 0.873 |
| Problem Identification | 4 | 0.886 |
| Experimental Operation | 4 | 0.894 |
| Data Analysis | 4 | 0.901 |
| Achievement Application | 4 | 0.867 |
| Research Efficacy | 10 | 0.935 |
| Influencing Factors | 30 | 0.962 |
| Overall Questionnaire | 75 | 0.958 |

Confirmatory factor analysis was carried out using AMOS 23.0, and the results showed that: CMIN/DF=4.217, RMSEA=0.067, NFI=0.912, CFI=0.928, IFI=0.929, TLI=0.915, and all indicators met the adaptation standards, indicating that the scale had good construct validity.

4. Research Findings

4.1 Descriptive Statistics and Difference Analysis

4.1.1 Group Differences in Scientific Research Ability and Research Efficacy

The total score of scientific research ability of students who received tutor guidance was (3.58 ± 0.62), which was significantly higher than that of those who did not receive guidance (3.15 ± 0.65). Independent sample t-test showed $t=7.289$, $P<0.001$; the score of research efficacy (3.7215 ± 0.68) was also significantly higher than that of those who did not receive guidance (3.5102 ± 0.70), $t=3.217$, $P<0.001$ (see Table 3).

Table 3. Independent Samples T-test for Tutor Guidance Group or Non-Guidance Group

| Variable | Guidance Group (n=452) | Non-Guidance Group (n=271) | t Value | P Value |
|--|---------------------------|-------------------------------|---------|---------|
| Total Score of Scientific Research Ability | 3.58±0.62 | 3.15±0.65 | 7.289 | <0.001 |
| Literature Retrieval Ability | 3.47±0.71 | 3.12±0.69 | 5.214 | <0.001 |
| Problem Identification Ability | 3.62±0.65 | 3.23±0.67 | 6.382 | <0.001 |
| Experimental Operation Ability | 3.55±0.68 | 3.10±0.70 | 6.457 | <0.001 |
| Data Analysis Ability | 3.49±0.73 | 3.11±0.72 | 5.481 | <0.001 |
| Achievement Application Ability | 3.70±0.63 | 3.31±0.66 | 6.823 | <0.001 |
| Research Efficacy | 3.7215±0.68 | 3.5102±0.70 | 3.217 | <0.001 |

4.1.2 Correlation between Student Individual Factors and Scientific Research Ability

Pearson correlation analysis was carried out on 452 students who received tutor guidance, and the results showed that:

Research motivation was significantly positively correlated with scientific research ability ($r=0.412$, $P<0.001$), among which the correlation coefficient between intrinsic motivation and achievement application ability was the highest ($r=0.487$);

Professional performance was significantly positively correlated with scientific research ability ($r=0.389$, $P<0.001$), especially with experimental operation ability ($r=0.456$) and data analysis ability ($r=0.432$);

Critical thinking score was significantly positively correlated with problem identification ability ($r=0.521$, $P<0.001$);

Research efficacy was strongly correlated with all dimensions of scientific research ability ($r=0.586\sim 0.673$, $P<0.001$), among which the correlation coefficient with achievement application ability was the highest ($r=0.673$).

4.2 Regression Analysis of Tutor Guidance on Scientific Research Ability

4.2.1 Analysis of Overall Impact

After controlling individual factors such as gender, grade, and major, a multiple regression model was constructed (see Table 4). The results showed that:

When only control variables were included in Model 1, $R^2=0.187$, $F=5.328$, $P<0.001$, indicating that control variables could explain 18.7% of the variation in scientific research ability;

After adding the tutor guidance variable in Model 2, $R^2=0.362$, $F=12.874$, $P<0.001$, the explanatory power increased by 17.5% compared with Model 1, indicating that tutor guidance could significantly improve scientific research ability ($\beta=0.362$, $P<0.001$), and H1 was established.

After adding the research efficacy variable in Model 3, $R^2=0.541$, $F=21.365$, $P<0.001$, the standardized regression coefficient of research efficacy on scientific research ability was 0.531 ($P<0.001$), H3 was established, and the regression coefficient of tutor guidance decreased to 0.247 ($P<0.001$), indicating that research efficacy might play a mediating role.

Table 4. Analysis of Factors Influencing the Scientific Research Capability of Undergraduates

| Variable | Model 1 (Control Variables) | Model 2 (+ Tutor Guidance) | Model 3 (+ Research Efficacy) |
|--------------------------|-----------------------------|----------------------------|-------------------------------|
| Gender (Male=1) | 0.123* | 0.115* | 0.092+ |
| Grade (Freshman=1) | -0.087+ | -0.079+ | -0.065 |
| Major (Engineering=1) | 0.156** | 0.148** | 0.132* |
| Professional Performance | 0.217** | 0.189** | 0.125* |
| Research Motivation | 0.235** | 0.201** | 0.117+ |
| Tutor Guidance | — | 0.362** | 0.247** |
| Research Efficacy | — | — | 0.531** |
| R^2 | 0.187 | 0.362 | 0.541 |
| ΔR^2 | — | 0.175** | 0.179** |
| F Value | 5.328** | 12.874** | 21.365** |

Notes. + $P<0.1$, * $P<0.05$, ** $P<0.01$, *** $P<0.001$, the same below.

4.2.2 Impact Analysis of Each Dimension of Tutor Guidance

Tutor guidance was decomposed into three dimensions: guidance frequency, guidance method, and guidance content, and regression models were constructed respectively (see Table 5). The results showed that:

The guidance frequency had a significant positive impact on scientific research ability ($\beta=0.315$, $P<0.001$), and H1a was established.

The guidance method had a significant positive impact on scientific research ability ($\beta=0.332$, $P<0.001$), and H1b was established.

The guidance content had a significant positive impact on scientific research ability ($\beta=0.357$, $P<0.001$), and H1c was established.

The impact of guidance content was relatively large, possibly because it directly involved scientific research methods and achievement output.

Table 5. Analysis of the Impact of Various Dimensions of Tutor Guidance

| Variable | Model 4 (Guidance Frequency) | Model 5 (Guidance Method) | Model 6 (Guidance Content) |
|--------------------|------------------------------|---------------------------|----------------------------|
| Control Variables | 0.187** | 0.187** | 0.187** |
| Guidance Frequency | 0.315*** | — | — |
| Guidance Method | — | 0.332*** | — |
| Guidance Content | — | — | 0.357*** |
| R ² | 0.346 | 0.361 | 0.382 |
| ΔR^2 | 0.159*** | 0.174*** | 0.195*** |
| F Value | 11.726*** | 12.543*** | 13.872*** |

4.3 Mediating Effect Analysis of Research Efficacy

The mediating effect was tested using the PROCESS plugin (Model 4), and Bootstrap repeated sampling was set to 5000 times. The results showed (see Table 6):

The total effect of tutor guidance on scientific research ability was significant ($\beta=0.071$, $P<0.001$);

The direct effect was significant ($\beta=0.054$, $P<0.001$);

The indirect effect was significant ($\beta=0.017$, 95% CI: 0.0092~0.0251), accounting for 23.9% of the total effect, indicating that research efficacy played a partial mediating role between tutor guidance and scientific research ability, and H4 was established.

Table 6. Analysis of the Mediating Effect of Research Efficacy

| Effect Type | Effect Value | SE | t Value | P Value | 95% CI (Lower Limit) | 95% CI (Upper Limit) | Proportion of Mediating Effect |
|-----------------|--------------|-------|---------|---------|----------------------|----------------------|--------------------------------|
| Total Effect | 0.071 | 0.008 | 8.875 | <0.001 | 0.055 | 0.087 | — |
| Direct Effect | 0.054 | 0.007 | 7.714 | <0.001 | 0.040 | 0.068 | — |
| Indirect Effect | 0.017 | 0.004 | — | — | 0.0092 | 0.0251 | 23.9% |

From the perspective of each dimension of tutor guidance, the mediating effects of research efficacy were all significant (see Table 7):

The indirect effect of guidance frequency was 0.013 (95% CI: 0.0061~0.0212), accounting for 20.6% of the total effect;

The indirect effect of the guidance method was 0.015 (95% CI: 0.0073~0.0235), accounting for 22.4% of the total effect;

The indirect effect of guidance content was 0.019 (95% CI: 0.0098~0.0287), accounting for 25.3% of the total effect, indicating that guidance content had the strongest impact on scientific research ability through research efficacy, and H4a, H4b, and H4c were established.

Table 7. Analysis of the Mediating Effect of Each Dimension of Tutor Guidance on Research Efficiency

| Dimension | Total Effect | Direct Effect | Indirect Effect | Proportion of Mediating Effect |
|--------------------|--------------|---------------|-----------------|--------------------------------|
| Guidance Frequency | 0.063 | 0.050 | 0.013 | 20.6% |
| Guidance Method | 0.067 | 0.052 | 0.015 | 22.4% |
| Guidance Content | 0.075 | 0.056 | 0.019 | 25.3% |

4.4 Moderating Effect Analysis of Multidimensional Influencing Factors

In order to explore the moderating effect of student individuality, university environment, and other factors on the relationship between tutor guidance and scientific research ability, a hierarchical moderating model was constructed with scientific research ability as the dependent variable (see Table 8).

4.4.1 Moderating Effect of Student Individual Factors

Research motivation had a significant moderating effect on the effect of tutor guidance ($\beta=0.182$, $P<0.001$). Simple slope analysis showed that the impact of tutor guidance on scientific research ability in the intrinsic motivation group ($\beta=0.415$, $P<0.001$) was stronger than that in the extrinsic motivation group ($\beta=0.273$, $P<0.001$);

Professional foundation had a significant moderating effect on the effect of tutor guidance ($\beta=0.156$, $P<0.01$). The impact of tutor guidance on students with professional scores in the top 30% ($\beta=0.432$, $P<0.001$) was significantly higher than that on students in the bottom 30% ($\beta=0.247$, $P<0.001$).

4.4.2 Moderating Effect of University Environment Factors

Laboratory resources had a significant moderating effect on the effect of tutor guidance ($\beta=0.127$, $P<0.05$). The impact of tutor guidance in universities with abundant resources ($\beta=0.398$, $P<0.001$) was stronger than that in universities with scarce resources ($\beta=0.285$, $P<0.001$).

School-enterprise cooperation platform had a significant moderating effect on the effect of tutor guidance ($\beta=0.143$, $P<0.01$). The impact of tutor guidance in universities with cooperation bases ($\beta=0.411$, $P<0.001$) was significantly higher than that in universities without bases ($\beta=0.269$, $P<0.001$).

4.4.3 Moderating Effect of System Support Factors

Scientific research incentive policies had a significant moderating effect on the effect of tutor guidance ($\beta=0.135$, $P<0.05$). The impact of tutor guidance in universities with incentive policies ($\beta=0.386$, $P<0.001$) was stronger than that in universities without policies ($\beta=0.271$, $P<0.001$).

The practical assessment mechanism had a significant moderating effect on the effect of tutor guidance ($\beta=0.162$, $P<0.01$). The impact of tutor guidance in universities with practice-oriented assessment ($\beta=0.403$, $P<0.001$) was more significant.

Table 8. Analysis of the Regulatory Effect of Multidimensional Influencing Factors

| Variable | Model 7 (Control Variables) | Model 8 (+ Individual Factors) | Model 9 (+ University Environment) | Model 10 (+ Institutional Support) |
|--------------------------------------|-----------------------------|--------------------------------|------------------------------------|------------------------------------|
| Control Variables | 0.187** | 0.187** | 0.187** | 0.187** |
| Tutor Guidance | 0.362*** | 0.362*** | 0.362*** | 0.362*** |
| Research Motivation | — | 0.235*** | 0.235*** | 0.235*** |
| Professional Foundation | — | 0.217*** | 0.217*** | 0.217*** |
| Laboratory Resources | — | — | 0.176*** | 0.176*** |
| School-Enterprise Cooperation | — | — | 0.154*** | 0.154*** |
| Scientific Research Incentives | — | — | — | 0.142** |
| Assessment Mechanism | — | — | — | 0.135* |
| Tutor Guidance × Research Motivation | — | 0.182*** | 0.182*** | 0.182*** |

Table 8 Continued

| Variable | Model 7 (Control Variables) | Model 8 (+ Individual Factors) | Model 9 (+ University Environment) | Model 10 (+ Institutional Support) |
|---|--------------------------------|-----------------------------------|---------------------------------------|------------------------------------|
| Tutor Guidance × Professional Foundation | — | 0.156** | 0.156** | 0.156** |
| Tutor Guidance × Laboratory Resources | — | — | 0.127* | 0.127* |
| Tutor Guidance × School-Enterprise Cooperation | — | — | 0.143** | 0.143** |
| Tutor Guidance × Scientific Research Incentives | — | — | — | 0.135* |
| Tutor Guidance × Assessment Mechanism | — | — | — | 0.162** |
| R ² | 0.362 | 0.487 | 0.563 | 0.621 |
| ΔR ² | — | 0.125*** | 0.076*** | 0.058*** |
| F Value | 12.874*** | 15.632*** | 18.257*** | 20.346*** |

5. Conclusions and Recommendations

5.1 Research Conclusions

Tutor guidance is a key path to improve the scientific research ability of undergraduates in application-oriented universities: The scientific research ability of students who received tutor guidance was significantly higher than that of those who did not, indicating that tutor guidance can effectively promote students to transform from scientific research novices to practical researchers. The three dimensions of guidance frequency, method, and content all had positive impacts on scientific research ability, among which the technical support of guidance content was the most significant.

Research efficacy plays a mediating role between tutor guidance and scientific research ability: Tutor guidance promotes the improvement of scientific research ability by enhancing students' research efficacy (that is, confidence in their own scientific research ability), forming a transmission path of "guidance-efficacy-ability". The mediating effect accounted for 23.9%, among which the indirect influence of guidance content through research efficacy was the strongest (25.3%).

Multidimensional factors moderate the effect of tutor guidance: Students' individual characteristics (research

motivation, professional foundation), university environment (laboratory resources, school-enterprise cooperation), and institutional support (scientific research incentives, assessment mechanisms) all significantly moderate the relationship between tutor guidance and scientific research ability. For example, students with strong intrinsic motivation and good professional foundation benefit more from tutor guidance; universities with rich practical platforms and incentive policies have more significant tutor guidance effects.

5.2 Practical Recommendations

5.2.1 Optimize the Content and Method of Tutor Guidance

Content optimization: Establish an “application-oriented” guidance content system, for example: Engineering majors add a guidance module of “patent writing and technology transformation”; Science majors strengthen the training of “data analysis tools and industry applications”; humanities majors add the guidance of “corporate mentor and critical thinking courses”.

Method innovation: Implement a “three-dimensional guidance model”: Online real-time guidance: Use scientific research management platforms (such as Researcher Link) to achieve real-time feedback on problems; Laboratory practical demonstration: Carry out on-site demonstration for operational contents such as instrument use and experimental design; Enterprise on-site guidance: Lead students to the production front line to solve practical technical problems (such as production line fault diagnosis).

5.2.2 Strengthen the Cultivation Mechanism of Research Efficacy

Process motivation: Tutors should set ladder research goals, give specific feedback on phased achievements (such as “Your data visualization scheme is very innovative”), and gradually enhance students’ scientific research confidence.

Model demonstration: Organize “scientific research pacesetter” experience sharing sessions, and invite students with high research efficacy to introduce their scientific research experience from failure to success.

5.2.3 Improve the Support System for Scientific Research Ability Cultivation

University environment construction: Increase investment in scientific research hardware and build laboratories in line with industry (such as intelligent manufacturing laboratories, big data analysis platforms); Expand school-enterprise cooperation bases and build at least 5 scientific research practice centers with local enterprises every year.

System support innovation: Incorporate scientific research achievements into the credit system (such as 1 patent can be exchanged for 2 credits) and set up “applied scientific research scholarships”; Reform the assessment mechanism, the score of enterprise tutors on project application value accounts for no less than 30%, and add the assessment index of “achievement transformation effect”.

6. Research Limitations and Prospects

Although this study has revealed the mechanism of tutor guidance on the scientific research ability of undergraduates in application-oriented universities, there are still the following limitations:

Research method: Only cross-sectional data are used, which makes it difficult to reveal the dynamic development relationship between tutor guidance and scientific research ability. Longitudinal research can be carried out in the future.

Sample range: Only 3 application-oriented universities are selected, and the geographical coverage is limited. The sample range can be expanded in the follow-up to compare the differences of universities in different regions.

Influencing factors: The immediate impact of social environment factors (such as changes in industry policies) has not been deeply discussed, and case studies can be combined for supplementary analysis.

Future research can be explored in the following directions:

(1) Construct a development model of “tutor guidance-research efficacy-scientific research ability” to explore the role differences in different grade stages.

(2) Carry out multi-university comparative research to analyze the differences in tutor guidance mechanisms between “Double-First Class” universities and application-oriented universities.

(3) Combine artificial intelligence technology to develop an “intelligent scientific research guidance system” to achieve personalized matching and effect prediction of guidance methods.

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