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Investigation on the Development of Undergraduate Academic Literacy and Its Influencing Factors: A Case Study of Students from Beijing Normal University

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Abstract

The cultivation of undergraduate academic literacy is of great significance to the development of universities and students themselves. This research took the undergraduates of Beijing Normal University as an example, investigated the academic literacy level through questionnaire, and explored the impact of digital literacy and social network on academic literacy. This research tested hypotheses and model through variance analysis, regression analysis, structural equation and other data analysis methods, and found that both digital literacy and social network have a significant positive impact on academic literacy, and that digital literacy and social network are mutually intermediary variables. Based on this, suggestions were given for undergraduate academic literacy cultivation.

Keywords

Academic Literacy, Digital Literacy, Social Network

1. Introduction

1.1. Background

Facing the challenge of talent training in the 21st century, many universities have put forward the objective of building a world-class university. As the reserve force for scientific research, the cultivation of undergraduate students' academic literacy will affect the improvement of scientific research in universities, making it important for the future development of colleges and universities (Wang, 2017). For undergraduates, the cultivation of academic literacy is con-

ducive to the improvement of their own abilities and plays a key role in graduation, further education and employment. At present, some colleges and universities have provided many opportunities for undergraduates to carry out academic activities. However, many sectors of society still believe that the academic literacy level of undergraduates needs to be improved.

The development of academic literacy needs the support of both internal ability and external environment. With the rapid development of information technology, traditional academic research is facing new challenges brought by the digital environment. In order to better meet these challenges, researchers need to have good abilities in data collection, analysis, evaluation, and storage, as well as the ability to use information technology for collaboration and communication (Yang, 2020). These abilities are components of digital literacy. Therefore, good digital literacy is conducive to the development of academic literacy. In addition, the development of undergraduate academic literacy cannot be separated from the support of social networks (Huang & Cui, 2019). Students can learn about the cutting-edge progress of the discipline in the communication with their tutors, and they can also find opportunities to participate in academic projects and competitions through their own interpersonal relationships. It can be seen that digital literacy and social networks may be important factors affecting students' academic literacy.

1.2. Research Issues

This research focused on the following three key issues:

1) What is the connotation of academic literacy? What dimensions are included?

2) What is the academic literacy level of the undergraduate group? How should we evaluate the academic literacy of undergraduates?

3) How do digital literacy and social networks affect undergraduate academic literacy? What is the impact mechanism?

2. Literature Review

This research mainly explored the development of undergraduate academic literacy and its influencing factors. Therefore, this research reviewed academic literacy, digital literacy, and social networks in order to provide academic support for subsequent research.

2.1. Academic Literacy

The researches on academic literacy were mostly focused on the academic literacy of postgraduates, and different researchers had different understandings of the connotation and components of the academic literacy of postgraduates. A researcher reviewed the relevant research on the academic literacy of postgraduate students in recent years, and found that most researchers thought the academic literacy referred to the comprehensive literacy and ability of postgraduate

students in academic research (Xie, 2019). Liu Qiancheng et al. thought that the components of postgraduate academic literacy included theoretical literacy, methodological literacy, independent inquiry literacy, tracking academic frontier literacy, expanding academic territory literacy, and good academic attitude (Yu & Shi, 2016). An Jing et al. thought that it included fearless spirit, independent consciousness, critical thinking, and affection (An & Wang, 2013). Yu Ji et al. believed that it included curiosity in knowledge, enthusiasm for exploring, ability of independent research, thinking, knowledge and skills (Liu & Liu, 2012). Wang Lizhen et al. believed that the academic literacy of postgraduates included academic awareness, academic knowledge, academic ability and academic ethics (Wang, Yuan, & Ma, 2012), and the specific framework is shown in Table 1. Researchers also studied the academic literacy of different professional groups such as university teachers, academic journal editors and university research managers. The academic literacy of minors and undergraduates has also been discussed, but the number of relevant studies is not very large.

Table 1. The dimensions of academic literacy.

Dimension	Connotation	Components
Academic awareness	Academic awareness refers to the conscious and rational response to academic research activities and the sensitivity to academic information, which is the internal motivation for scientific exploration.	-
Academic knowledge	Academic knowledge refers to the professional knowledge system formed by postgraduates in the process of systematic learning and academic research.	General scientific and cultural knowledge Subject expertise Methodology knowledge
Academic ability	Academic ability refers to the relevant ability and quality necessary for academic research.	Academic innovation ability Professional choice and judgment Academic resources acquisition ability Research process design ability Academic papers writing ability
Academic ethics	Academic ethics refers to the sum of values and academic norms widely recognized in the academic research field that researchers abide by in their academic activities.	-

Many researches have discussed the cultivation of postgraduate academic literacy, and few researches have discussed the cultivation of undergraduate academic literacy. The cultivation of postgraduate academic literacy is faced by the challenges in enhancing postgraduate innovation awareness, increasing opportunities for academic research activities, optimizing postgraduate curriculum, improving postgraduate research conditions, and strengthening guidance of tutors. In fact, the level of undergraduate academic literacy can also be improved from these aspects.

2.2. Digital Literacy

With the development of digital technology and the improvement of human cognitive level, the connotation of digital literacy is also deepening and expanding. In 1997, Paul Gilster formally put forward the term "digital literacy", and defined it as being able to retrieve information on the Internet and understand the meaning behind links, while having critical thinking and integration capabilities (Gilster, 1997). In 2004, Eshet-Alkalai proposed five frameworks of digital literacy: picture-image literacy, recreation literacy, branch literacy, information literacy and social-emotional literacy (Eshet-Alkalai, 2004), and in 2012, real-time thinking skill was also included in the digital literacy framework (Eshet-Alkalai, 2012). IFLA pointed out that having digital literacy meant that people could maximize the use of digital technology under efficient and reasonable conditions to meet the information needs of individuals, society and professional fields (He, 2017). Allan Martin et al. defined digital literacy as the awareness, attitude and ability of individuals to correctly use digital tools and equipment, build new knowledge, innovate media expression and communicate with others in specific situations (Martin & Grudziecki, 2006). In 2013, the EU formulated DigComp, a digital literacy framework for all European citizens, which provided a reference for the establishment of digital literacy education model. Since 2015, the European Union has revised the framework and launched the DigComp2.0, 2.1 and 2.2. DigComp2.0 includes five literacy domains: information and data, communication and collaboration, digital content creation, security, and problem solving. The five domains also include multiple specific literacy domains (Vuorikari, Punie, Carretero Gomez, & Van Den Brande, 2016).

2.3. Social Network

Barnes was the first to propose the concept of "social network", which was used to express informal contacts beyond formal relationships (Barnes, 1954). Later, Mitchell regarded both formal and informal interpersonal relationships as social networks (Mitchell, 1969). Cook extended the concept of network to the organizational level, and defined the network between organizations as "the joint exchange relationship between two or more organizations" (Cook, 1982). Laumann, Galaskiewicz and Marsden further expanded the concept of social network and defined social network as the connection formed by individuals, groups, organizations, countries and other nodes through specific social relations (Lau-

mamr, Galaskiewicz, & Marsden, 1978).

There are many different views on the measurement of social networks. Tichy, Tushman and Fombrun proposed to measure various characteristics of interpersonal networks by transaction content, connection characteristics and structural characteristics (Tichy, Tushman, & Charles, 1979). Whetten proposed network characteristics, including centrality, complexity and density (Whetten, 1982). Davern believed that social networks should include four dimensions: structure, resources, norms and dynamic processes (Davern, 1997). Based on the above views, Zhou Xing et al. considered that college students' social networks could be divided into four aspects: network centrality, network connection strength, network heterogeneity, and network dynamics (Zhou, 2008):

1) Network centrality refers to the amount of direct and indirect relationships that individuals establish with others. The more centrality members have, the greater the degree of assets, information, and status advantages they can master. Freeman et al. summarized three metrics on centrality, namely, breadth, closeness and intermediary degree (Freedman & Tregoe, 2003).

2) Network connection strength refers to the degree of closeness of the members constituting the social network. Granovertter pointed out that it could be measured from four dimensions: interaction time, emotional intensity, intimacy and reciprocal service (Granovertter, 1982).

3) Network heterogeneity refers to the degree of difference between various attributes of each node in the social network. The importance of heterogeneity is mainly reflected in the fact that heterogeneous social networks provide a large amount of non-repetitive information.

4) Davern believed that the dynamic process of social networks could be understood from three dimensions: network construction, relationship maintenance and resource mobilization (Davern, 1997).

3. Research Design

3.1. Research Model and Assumptions

This research explored the academic literacy level of undergraduates, and analyzed the impact of digital literacy and social networks on academic literacy and the interaction between them. The conceptual model of this study is shown in Figure 1.

1) The influence of digital literacy on academic literacy

Students with high digital literacy tend to have strong ability in information retrieval, processing and analysis, which can provide better support for academic activities. At the same time, these students can better communicate and collaborate with others through digital technologies, which is conducive to obtaining valuable academic knowledge and information. They are also more likely to use digital technologies to create works related to their majors and solve professional problems. Based on the above analysis, this research proposed the following assumption:
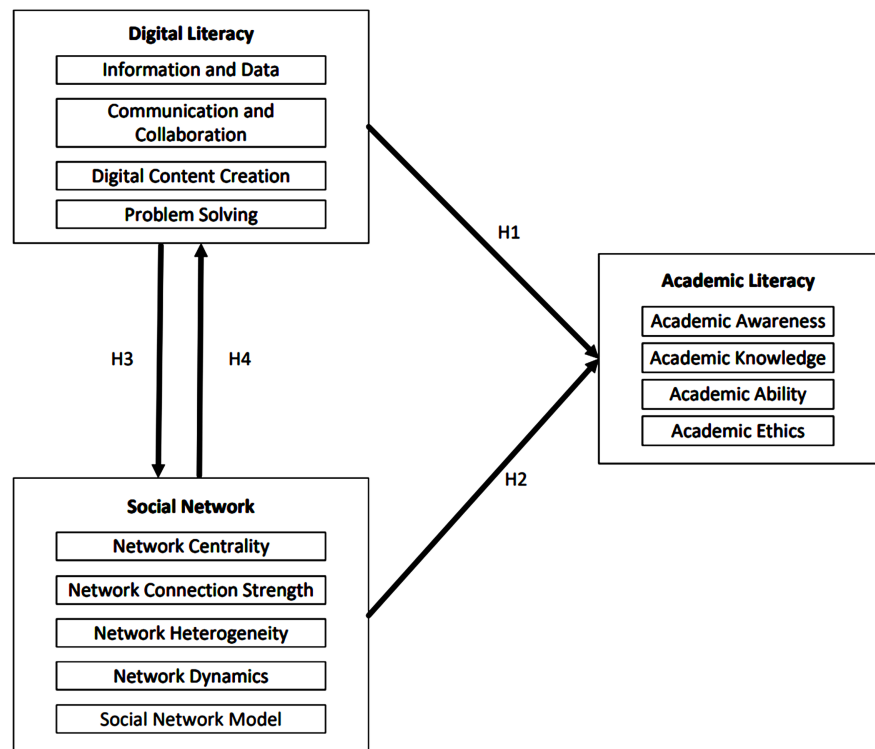
Figure 1. Conceptual model.

H1: Digital literacy has a significant positive impact on academic literacy.

2) The influence of social network on academic literacy

In the process of academic research, researchers need to interact with others to obtain support in knowledge, technology, capital, manpower, etc. Therefore, students' social networks may have an impact on the development of academic literacy. Individuals with stronger network centrality are more likely to have access to important information and resources and participate in scientific research projects. Individuals with stronger relationship networks can obtain higher level of support and higher quality information, and then conduct research activities better. Students with stronger network heterogeneity can obtain more valuable and non-repetitive knowledge, views and opportunities. The more social network nodes individuals have, the more people individuals can exchange information and resources with. Based on the above analysis, this research proposed the following assumption:

H2: Social network has a significant positive impact on academic literacy.

3) The interaction between digital literacy and social network

Students with higher digital literacy are more capable of communication and collaboration, which is conducive to the establishment and maintenance of interpersonal relationships. In addition, they can better express themselves through digital content, which will increase their attractiveness and is helpful to build more connections with others. Students with a wider social network can access more digital information and data, which is conducive to the development of information collection and analysis ability in a subtle way. Students with more friends

tend to communicate more with others on social media, and express themselves more frequently through text, pictures and videos. Based on the above analysis, this research proposed the following assumptions:

H3: Digital literacy has a significant positive impact on social network.

H4: Social network has a significant positive impact on digital literacy.

3.2. Research Plan and Process

3.2.1. Research Process Design

This research explored the development of undergraduate academic literacy, and the impact mechanism of digital literacy and social networks on academic literacy. According to the purpose and idea of this research, the whole research process is shown in **Figure 2**.

3.2.2. Research Method

1) Literature survey method

This research used the literature survey method to investigate the Chinese and English literature on academic literacy and its influencing factors, mainly including the definitions and measurement dimensions of academic literacy, digital literacy and social networks, and summarized the characteristics and shortcomings of existing research. On this basis, the theoretical framework model of this research was constructed and relevant research assumptions were proposed.

2) Questionnaire survey method

In this research, a questionnaire survey was used to test the research hypotheses from a quantitative perspective. Firstly, this research drew on the mature theoretical framework and scales in existing studies to determine the main dimensions of the questionnaire. Then, the reliability and validity of the questionnaire were verified by factor analysis and unnecessary items were screened to form the final questionnaire.

3) Data demonstration method

This research used correlation analysis, variance analysis, regression analysis and structural equation to process the collected data, verify the proposed theoretical assumptions, and explore the development level of undergraduate academic literacy, as well as the impact mechanism of academic literacy and social networks on academic literacy.
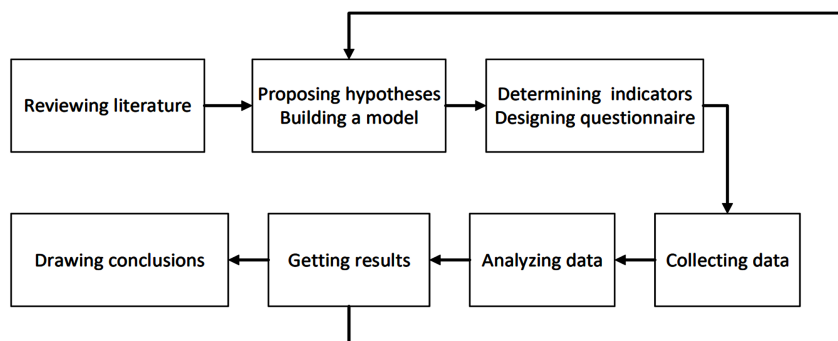

Figure 2. Research process.

3.3. Survey Index Design

The main body of the questionnaire in this research included four parts: basic personal information of undergraduates, academic literacy measurement, digital literacy measurement, and social network measurement. The questionnaire adopted the internationally accepted Likert five level scoring method. The "completely disagree" score was 1, the "relatively disagree" score was 2, the "uncertain" score was 3, the "relatively agree" score was 4, and the "completely agree" score was 5.

3.3.1. Measurement Indicators of Academic Literacy

The measurement of academic literacy in this research was mainly based on the theoretical framework of Wang Lizhen et al., and was carried out from four dimensions: academic awareness, academic knowledge, academic ability and academic ethics. Among them, the connotation and components of academic awareness, academic knowledge and academic ethics remained unchanged, while those of academic ability changed. In the dimensions of academic ability divided by Wang Lizhen et al., the focus of academic resource acquisition ability and academic paper writing ability is particularly detailed and has little content. And the academic innovation ability and professional selection and judgment ability are difficult to measure. After experts' discussion, this research divided academic ability into resource acquisition ability, research process design ability and academic normalization. The academic literacy framework of this research is shown in Figure 3.

In terms of resource acquisition ability, this research measured from the perspective of resource content. Through literature analysis, this research divided resources into five categories, namely facility resources, human resources, technical resources, information resources, knowledge and data resources. In the measurement of research process design ability, this research drew on description given by Wang Lizhen et al. and decided to focus on the design of research objectives, research processes and research methods. In terms of academic normalization, Chen Xuefei believed that academic norms involved technology,
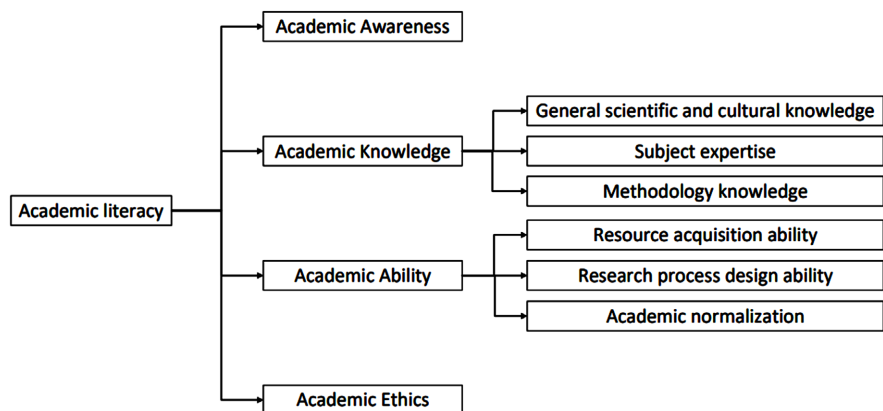

Figure 3. The academic literacy framework of this research.

content and morality (Chen, 2003). In order to avoid repetition with academic ethics, this research didn't consider the norms at the moral and ethical levels, but only considered the technical and content levels. The former usually refers to the academic form norms, while the latter mainly refers to the academic content requirements.

As academic literacy is not only related to students' subjective cognition, but also a highly objective indicator, in order to more truly measure the academic literacy level of undergraduates, this research added some objective questions about academic performance in the questionnaire, such as "How many papers have you published", and finally determined 23 items.

3.3.2. Measurement of Digital Literacy and Social Network

This research measured digital literacy based on the EU DigComp2.0 framework, and deleted the security domain that has no direct connection with academic literacy. In addition, this research also referred to the EU DigCompSat scale (Clifford, Kluzer, Troia, Jakobsone, & Zandbergs, 2020), combined with expert opinions, and finally established 16 items.

In the social network part, this research measured the network centrality, network connection strength, network heterogeneity, network dynamics and social network model. Network centrality was measured from three aspects: universality, closeness and intermediary. Network connection strength was measured from four aspects: interaction time, emotional intensity, relationship closeness and reciprocal action. Network heterogeneity was measured from three aspects: geographical distribution, professional background and age. Network dynamics were measured from two aspects: new cooperation establishment and cooperation maintenance. In view of the fact that we have entered the information age, information and information technology affect our interpersonal communication all the time. We can not only conduct face-to-face traditional social interaction, but also online social interaction. Therefore, in addition to these four dimensions, this research also considered the social network model, mainly including the traditional dimension and the information dimension. In addition, this research referred to the questionnaires and scales of Niu Xuemei (Niu, 2017), Huang Manye et al., and finally established 17 items in combination with expert opinions.

3.3.3. Demonstration of the Reliability and Validity

1) Reliability

In order to ensure the high reliability of the collected data, filtering reverse test items were added for some problems in the questionnaire design stage. After obtaining the data, the mutual verification between the positive question and its reverse test item helped us eliminate invalid questionnaires. We first conducted a small-scale pre-survey using the Questionnaire Star platform, and a total of 98 questionnaires were collected. After the joint screening of filtering items and test items, 91 valid questionnaires and 7 invalid questionnaires were obtained. Cron-

bach's α was used in this research as a reliability evaluation indicator. The results are shown in Table 2. It can be seen that the reliability of the questionnaire is good.

2) Validity

In the questionnaire design stage, this research referred to a large number of classic empirical research questionnaires, which have been used by researchers for many times. At the suggestion of experts, we adjusted these questionnaire items and added items that could rigidly reflect students' academic performance, such as "How many papers have you published", to improve the validity of the questionnaire.

Secondly, by analyzing the data collected in the pre-survey, it was found that the KMO values corresponding to academic literacy, digital literacy and social network were 0.652, 0.812 and 0.813 respectively, and Bartlett's spherical test was also significant ($p < 0.001$), which meant that factor analysis was suitable. We carried out exploratory factor analysis on these three variables respectively, and extracted a factor with eigenvalue greater than 1. The factor load corresponding to each sub dimension of the three variables was more than 0.6, and the degree of commonness was more than 0.5, so the extracted common factors could effectively reflect their respective indicators. The interpretation rate of the cumulative variance of the three variables after factor rotation was greater than 50%, which meant that the information of the research item can be effectively extracted. Therefore, in general, the validity of the questionnaire is good.

4. Analysis and Discussion

This research distributed questionnaires to all undergraduates of Beijing Normal University, and 236 valid questionnaires were collected from the formal survey. In the sample, the proportion of males is 16.5% while the proportion of females is 83.5%. Students in grade 2021 are the most, accounting for 41.5%, followed by students in grade 2020 and 2019, accounting for 22.0% and 28.4% respectively, and students in grade 2018 are the least, accounting for 8.1%. The number of students majoring in literature and history is the largest, accounting for 46.2%, followed by science and engineering students, accounting for 43.2%, and the number of economics and management students and arts and sports students is the smallest, accounting for 7.6% and 3% respectively.

Because the number of observation variables included in each potential variable was different, the mean value of all observation variables was used as an indicator to measure the level of potential variables in the subsequent further analysis and processing of the data.

Table 2. Reliability analysis.

Variable	Cronbach's α
Academic literacy	0.914
Digital literacy	0.897
Social network	0.830

4.1. Overview of Undergraduate Academic Literacy Development

4.1.1. Overview of Undergraduate Academic Literacy Development

In the measurement of academic literacy, this research set both subjective and objective questions, and drew conclusions by comprehensively considering the answers to these questions, so as to avoid the conclusions being too affected by the subjective cognitive bias of students.

1) Analysis of answers to subjective questions

The scores of students in academic literacy and its sub dimensions are shown in Table 3. The overall average score of academic literacy is 3.42. Among the four sub-dimensions, the mean value of academic ethics is the highest (3.53), while that of academic knowledge is the lowest (3.28). Among the three sub-dimensions of academic ability, the mean value of research process design ability is the largest (3.51), and that of resource acquisition ability is the smallest (3.29).

The correlation coefficients between academic literacy and its four sub-dimensions are all greater than 0.7, indicating a strong correlation. Among them, the figure between academic ability and academic literacy is the largest (0.972), indicating that academic ability has the greatest impact on academic literacy. At the same time, the correlation coefficients between academic ability and its sub-dimensions are also greater than 0.8, showing a strong correlation. Among them, the figure between research process design ability and academic ability is the largest (0.901), indicating that research process design ability has the greatest impact on academic ability.

2) Analysis of answers to objective questions

The analysis of objective questions is shown in Figure 4. On the question "I can easily search the knowledge and data I need" (AL10), 56.4% of the students relatively agreed, 21.6% were uncertain, 12.3% relatively disagreed, 8.9% fully agreed, and 0.8% completely disagreed. On the question "I can quickly conduct a literature review to describe the research status at home and abroad" (AL18), 40.7% of the students relatively agreed, 30.1% were not sure, 21.6% relatively disagreed, 4.2% fully agreed, and 3.4% completely disagreed. On the question "I

Table 3. Academic literacy and its sub-dimension scores.

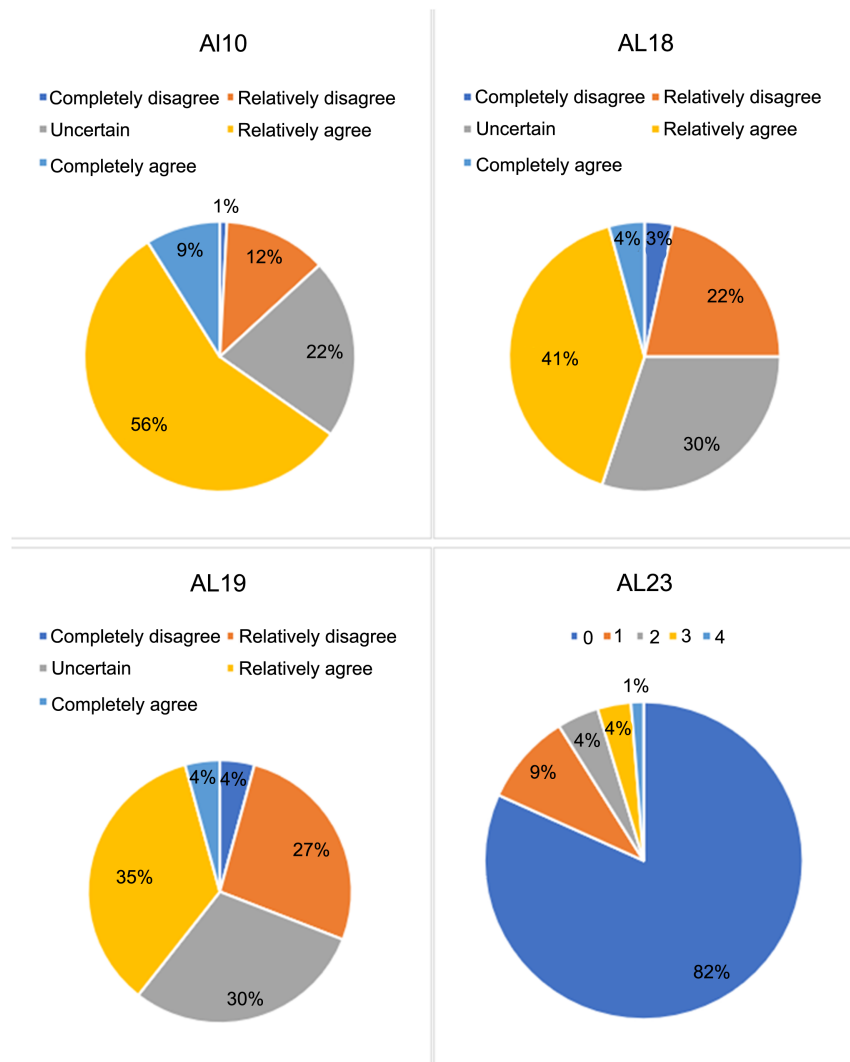|	Variable	Mean	Standard deviation
	Academic literacy	3.42	0.57
	Academic awareness	3.43	0.70
	Academic knowledge	3.28	0.68
Academic ability	Resource acquisition ability	3.29	1.00
	Research process design ability	3.51	1.00
	Academic normalization	3.47	1.50
	Total	3.43	1.62
	Academic ethics	3.53	0.69

Figure 4. The analysis of objective questions.

can write research papers quickly and achieve a good level" (AL19), 35.2% of the students relatively agreed, 29.7% were not sure, 26.7% relatively disagreed, 4.2% fully agreed, and the same number of students completely disagreed. In the item "How many papers have you published" (AL23), 81.8% of the students have not published any papers, 9.3% have published one paper, 4.2% have published two papers, 3.4% have published three papers, and 1.3% have published four papers.

The contents of the above four items are interrelated and progressive. The collection of knowledge and data is the basis of literature review, and literature review is the basis for writing papers. Paper writing is the premise for publishing papers. It can be clearly seen that with the increasing demand for ability, fewer and fewer students have a positive attitude towards their ability, and more and more students have an uncertain and negative attitude. And only a few students have the final academic achievements, that is, published papers.

3) Research on the relationship between paper publication and academic literacy scores

In order to explore the relationship between the number of papers issued and academic literacy, this research compared the academic literacy scores of students whose number of papers issued is 0, 1 and greater than 1, as shown in **Table 4**. In academic ethics, the p value is greater than 0.05, indicating that there is no significant difference in the scores of students with different number of papers. Students with more than one paper have the highest score, while students with no paper have the lowest score. On the whole and other sub dimensions of academic literacy, the students with one paper get the highest score. Among them, the p value of academic literacy, academic knowledge and academic ability is less than 0.05, indicating that students with different number of papers have significant differences in the scores of these three dimensions.

4.1.2. Overview of Undergraduate Digital Literacy and Social Network

The scores of students in digital literacy and its sub dimensions are shown in **Table 5**. The average digital literacy score is 3.80. Among the four sub dimensions, the average score of communication and collaboration is the highest (3.97), and the average of the other three dimensions is more than 3.7 and less than 3.8. The correlation coefficients between digital literacy and the four sub dimensions are greater than 0.7, indicating a strong correlation between them. The correlation coefficient between information and data literacy and digital literacy is the highest, exceeding 0.9.

The scores of students in social network and its sub dimensions are shown in **Table 6**. The average social network score is 3.54. Among the five sub dimensions,

Table 4. The scores of students with different number of papers in academic literacy.

Paper number	Academic awareness	Academic knowledge	Academic ability	Academic ethics	Academic literacy
0	3.37	3.22	3.38	3.50	3.37
1	3.68	3.62	3.67	3.61	3.66
Greater than 1	3.63	3.46	3.64	3.78	3.63
Total	3.43	3.28	3.43	3.53	3.42
Effect value (F)	2.97	4.30	3.81	1.71	4.15
Test probability (p)	0.05	0.02	0.02	0.18	0.02

Table 5. Digital literacy and its sub-dimension scores.

	Variable	Mean	Standard deviation
	Information and data literacy	3.78	0.54
	Communication and collaboration	3.97	0.62
Digital Literacy	Digital content creation	3.72	0.61
	Problem solving	3.78	0.62
	Total	3.80	0.49

Table 6. Social network and its sub-dimension scores.

Variable		Mean	Standard deviation
	Network centrality	3.26	0.654
	Network connection strength	3.78	0.706
Social network	Network heterogeneity	3.77	0.755
	Network dynamics	3.58	0.800
	Social network model	3.39	0.580
	Total	3.54	0.516

the average value of network connection strength and network heterogeneity is the highest (3.78 and 3.77), and the average value of network centrality is the lowest (3.26). The correlation coefficients between social network and the five sub dimensions are greater than 0.7, with strong correlation.

4.2. The Attribution Analysis of Undergraduate Academic Literacy

4.2.1. The Influence of Demographic Indicators on Academic Literacy

This research explored the influence of gender, grade, and major on undergraduate academic literacy through ANOVA. There is significant difference in the overall score of academic literacy among different genders ($p = 0.01$), and the score of male students is significantly higher than that of female students (male students score 3.63, female students score 3.38). There is no significant difference in the overall score of academic literacy among students in different grades ($p = 0.35$), but the scores of the 2019 and 2018 grades are higher than those of the 2021 and 2020 grades (3.40 for the 2021, 3.35 for the 2020, 3.53 for the 2019, and 3.46 for the 2018). There is significant difference in the overall score of academic literacy among students in different majors ($p = 0.04$). Arts and sports students score the highest (3.662), followed by science and engineering students, and economics and management students score the lowest (3.298).

In terms of paper publication, 46.2% of male students and 12.7% of female students have published papers; 9.2% of 2021 students, 17.9% of 2020 students, 28.8% of 2019 students, and 36.8% of 2018 students have published papers; 19.3% of the students majoring in literature and history, 13.7% of the students majoring in science and engineering, 22.2% of the students majoring in economics and management, and 57.1% of the students majoring in arts and sports have published papers.

4.2.2. The Influence of Digital Literacy and Social Network on Academic Literacy

1) The overall impact of digital literacy and social network on academic literacy

The regression analysis was conducted with digital literacy and social network as independent variables and academic literacy as dependent variable, and the "stepwise" independent variable screening method was selected. The R square of

the regression model with the best quality is 0.598, lower than 0.60, indicating that the quality of the model is average. In addition, VIF values in the model are all less than 5, which means that there is no serious collinearity problem. The D-W value is 1.980, indicating that there is no autocorrelation in the model and there is no correlation between the sample data. The coefficients of this model are shown in Table 7.

It can be seen that: a) The regression coefficient value of digital literacy is 0.551 ($p < 0.05$), which means that digital literacy has a significant positive impact on academic literacy. b) The regression coefficient of social network is 0.439 ($p < 0.05$), which means that social network has a significant positive impact on academic literacy. c) The standard coefficient of digital literacy is 0.474, and that of social network is 0.397. The former is greater than the latter, indicating that the impact of digital literacy on academic literacy is greater than that of social network.

2) The influence of digital literacy and social network sub dimension on academic literacy

With 9 sub dimensions of digital literacy and social network as independent variables and academic literacy as dependent variables, the regression analysis was conducted by selecting the "stepwise" independent variable screening method, and R square of the best regression model is 0.656. The VIF values in the model are all less than 5, which means that there is no serious collinearity problem. However, the regression coefficient of the communication and collaboration is negative, which is inconsistent with the actual situation. It may mean that the variable is affected by other variables, that is, the model still has a certain degree of collinearity.

Then the dimension of communication and collaboration was removed, and all other dimensions were used as independent variables for regression analysis again. The R square of the best regression model is 0.633, and the model coefficients are shown in Table 8. The VIF values in the model are all less than 5, which means that there is no serious collinearity problem. The D-W value is 2.027, indicating that the model does not have autocorrelation and there is no correlation between sample data.

It can be seen that: a) The regression coefficient values of digital content creation, information and data, problem solving, network centrality, social network model, and network heterogeneity are 0.225, 0.225, 0.184, 0.143, 0.134, and 0.098 ($p < 0.05$), which means that these six dimensions have a significant positive

Table 7. Model coefficients.

Model	Non-standardization coefficient		Standard coefficient	t	Sig.	VIF
	B	Standard error	Trial version			
Digital literacy	0.551	0.059	0.474	9.358	0.000	1.488
Social network	0.439	0.056	0.397	7.824	0.000	1.488

Table 8. Model coefficients.

Model	Non-standardization coefficient		Standard coefficient	t	Sig.	VIF
	B	Standard error	Trial version			
Digital content creation	0.225	0.053	0.240	4.251	0.000	1.980
Information and data	0.225	0.058	0.213	3.871	0.000	1.891
Network centrality	0.143	0.043	0.164	3.338	0.001	1.514
Problem solving	0.184	0.053	0.199	3.511	0.001	2.008
Social network mode	0.134	0.048	0.135	2.809	0.005	1.443
Network heterogeneity	0.098	0.035	0.130	2.793	0.006	1.359

impact on academic literacy. b) The two dimensions of network dynamics and network connection strength have not enterd the model, indicating that their impact on academic literacy is relatively insignificant. c) According to the standardization coefficient, digital content creation, information and data have the greatest impact on academic literacy, while social network model and network heterogeneity have the least impact on academic literacy. d) The model constructed is effective (Sig. is less than 0.05), has good quality (R square is greater than 0.6), and each coefficient value is in line with the actual situation.

4.2.3. Verification of Intermediary Paths

This research presupposed two intermediary paths: 1) digital literacy → social network → academic literacy; 2) social network → digital literacy → academic literacy. This research verified these two intermediary paths with the help of the Process plug-in of SPSS20.0 software.

1) Verification of path 1

We set the 95% confidence interval, and sampled 5000 times with the nonparametric percentile method of Bootstrapping deviation correction. The results are shown in Table 9. Social network plays a partial intermediary effect between digital literacy and academic literacy, with the intermediary effect value being 32.37% and the direct effect of digital literacy 67.63%.

2) Verification of path 2

We set the 95% confidence interval, and sampled 5000 times with the nonparametric percentile method of Bootstrapping deviation correction. The results are shown in Table 10. Digital literacy plays a partial intermediary effect between social network and academic literacy, with the intermediary effect value being 40.64% and the direct effect of social network 59.36%.

Based on the above analysis, we can draw a conclusion that digital literacy and social network act as intermediary variables and play a partial intermediary role in the process of influencing academic literacy.

Table 9. Analysis of intermediary effect of social network.

	Effect value	Boot standard error	Boot CI lower limit	Boot CI upper limit	Relative effect value
Total effect	0.8153	0.0542	0.7085	0.9220	
Direct effect	0.5514	0.0589	0.4353	0.6674	67.63%
Mediation effect	0.2639	0.0465	0.1781	0.3617	32.37%

Table 10. Analysis of intermediary effect of digital literacy.

	Effect value	Boot standard error	Boot CI lower limit	Boot CI upper limit	Relative effect value
Total effect	0.7389	0.0538	0.6329	0.8449	
Direct effect	0.4386	0.0561	0.3281	0.5490	59.36%
Mediation effect	0.3003	0.0471	0.2135	0.3984	40.64%

4.2.4. Confirmatory Analysis Based on Structural Equation Model

Using the AMOS plug-in of SPSS20.0 software, this research modelled and verified the theoretical framework proposed by the means of structural equation, as shown in Figure 5. The RMSEA value of the model is 0.068, indicating that the degree of fitting of the model is good. NFI = 0.923, CFI = 0.958, indicating that the quality of the model is good. In addition, all path coefficients in the structural equation model are statistically significant. The path coefficient between digital literacy and academic literacy is 0.53, and the figure between social network and academic literacy is 0.40, indicating that digital literacy has a greater impact on academic literacy. In the four dimensions of academic literacy, the path coefficient between academic ability and academic literacy is the largest (0.93), followed by academic knowledge, (0.80), indicating that academic ability and academic knowledge can best reflect the academic literacy of researchers. The path coefficient between social network and its five sub dimensions ranges from 0.64 to 0.72, with little difference. The figure between digital literacy and communication and collaboration is the smallest (0.70), and the other three dimensions have little difference.

4.3. Case-Oriented Cluster Analysis

Having a clear understanding of the development level of academic literacy and relevant key factors, we decided to do Cluster analysis for existing cases and explored the differences in academic literacy, digital literacy and social network scores between different Clusters, so as to provide effective strategies and reasonable suggestions for the improvement in academic literacy.

4.3.1. Cluster Center Distribution

In this research, K-means Clustering analysis method was used to analyze the samples. Three variables, academic literacy, digital literacy and social network, were taken into consideration. The "iteration and classification" method was
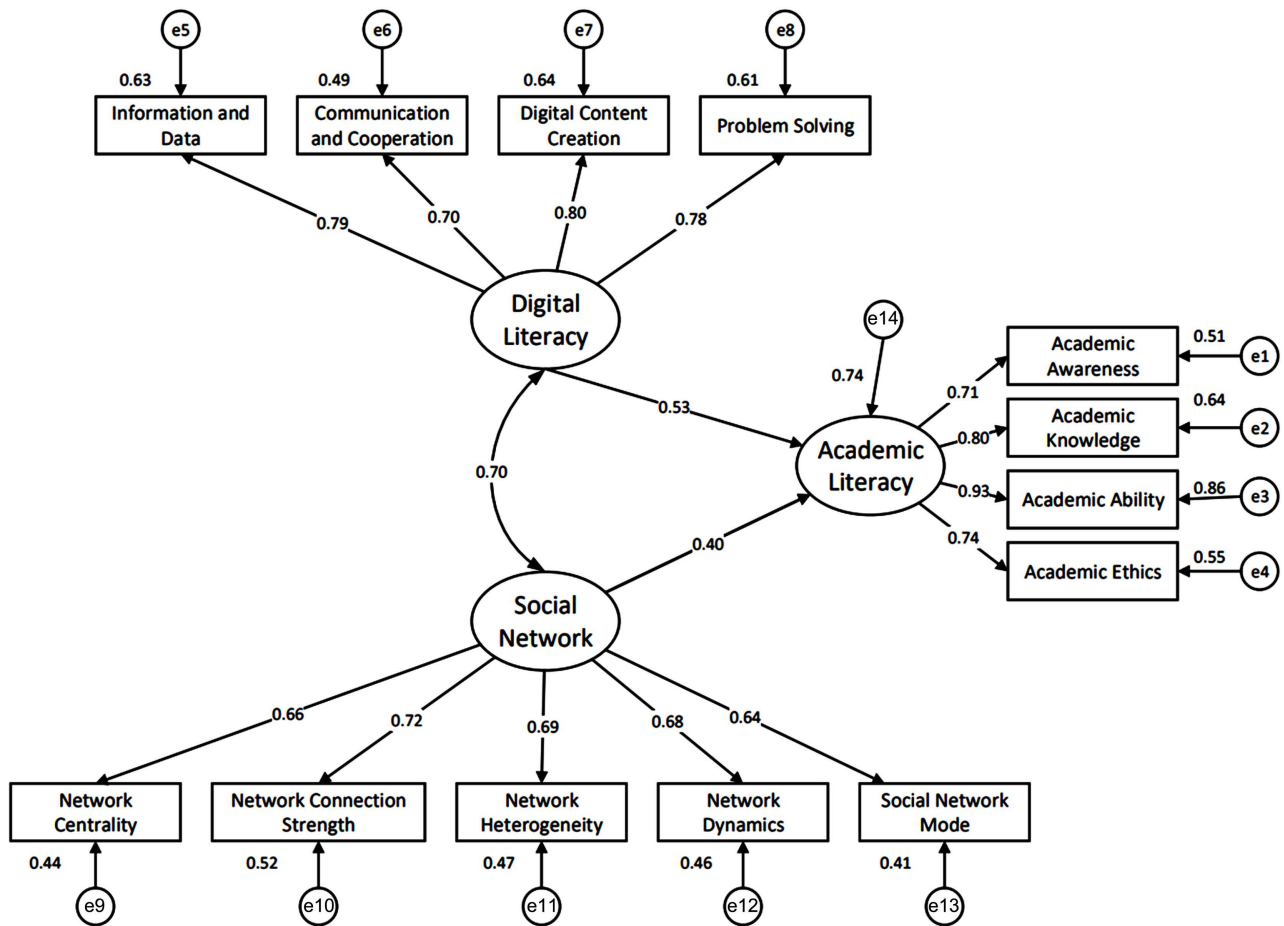
Figure 5. Structural equation analysis.

selected. Considering the balance of the number of cases in each Cluster and the effectiveness of data analysis, the final Cluster number was determined to be 4, and the Cluster center and proportion are shown in Table 11. By observing the Cluster center data, we can see that different Clusters have different characteristics. The scores of Cluster 1 in three dimensions are less than the average. Cluster 2 scored much higher than the average in three aspects. Cluster 3 scores higher than the average in academic literacy and social network, but slightly lower in digital literacy. Cluster 4 scores well below the average in three aspects. It can be summarized as follows: Cluster 1 is the group with relatively low self-assessment; Cluster 2 is the group with quite high self-evaluation; Cluster 3 is the group with relatively high self-evaluation; Cluster 4 is the group with quite low self-assessment.

4.3.2. Demographic Distribution of the Four Clusters

The demographic distribution of the students in the four Clusters is shown in Table 12. It can be found that there are more males in Cluster 2 and Cluster 3. There are more students in grade 2019 in Cluster 2 and more students in grade 2020 in Cluster 4. The distribution of majors in different Clusters is complex, with more students in arts and sports, science and engineering, and economics

Table 11. The final Cluster center based on academic literacy and its influencing factors.

Variable	Total	Cluster Center			
		1	2	3	4
Direct effect	0.4386	1	2	3	4
Academic literacy	3.42	3.13	4.29	3.62	2.55
Digital literacy	3.80	3.23	4.13	3.77	2.94
Social network	3.54	3.62	4.52	3.92	3.10
Case number	236	74	35	95	32
Percentage	100%	31.36%	14.83%	40.25%	13.56%

Table 12. Demographic distribution of students in different Clusters.

Variable		Total	Cluster 1	Cluster 2	Cluster 3	Cluster 4
Gender	Male	16.5%	13.5%	25.7%	17.9%	9.4%
	Female	83.5%	86.5%	74.3%	82.1%	90.6%
Grade	2021	41.5%	51.4%	42.9%	35.8%	34.4%
	2020	28.4%	21.6%	11.4%	35.8%	40.6%
	2019	22.0%	20.3%	40.0%	18.9%	15.6%
	2018	8.1%	6.8%	5.7%	9.5%	9.4%
Major	Literature and History	46.2%	54.7%	38.6%	34.3%	57.9%
	Science and Engineering	43.2%	40.0%	45.5%	57.1%	31.6%
	Economics and Management	7.6%	2.7%	10.2%	8.6%	10.5%
	Arts and Sports	3.0%	2.7%	5.7%	0.0%	0.0%

and management in Cluster 2, and more students in literature and history in Cluster 4.

4.3.3. Comparison of Different Clusters and Their Needs in Academic Literacy Development

1) Comparison among four Clusters

By analyzing all items of academic literacy, it is found that students in Cluster 2 have the highest scores on all items, followed by Cluster 3. Students in Cluster 1 and Cluster 4 have scores below the average, and students in Cluster 4 have the lowest scores. The same rule can be seen in the overall score and sub dimension scores of academic literacy.

By analyzing all items of digital literacy and social network, it is found that students in Cluster 2 have the highest scores on most items, followed by Cluster 3. The average scores of students in Cluster 1 and Cluster 4 are below the average, and students in Cluster 4 have the lowest scores. The same rule can be seen in the overall score and sub dimension scores of academic literacy and social network. However, the situation is different on a few items.

2) Comparison within Clusters

Students in Cluster 1 score more than 3.00 on most items. In terms of academic literacy, students in Cluster 1 score the lowest and less than 3.00 in academic knowledge. In the four dimensions of digital literacy, the scores are similar and relatively high. In terms of social network, the score in network centrality is the lowest. The students in Cluster 1 have low self-evaluation on academic knowledge and network centrality.

Students in Cluster 2 score more than 4.00 on most items. They score below 4.00 in items about personal dating, participating in class activities, mastering knowledge of research methods, and mastering data processing software. They may think that they are deficient in these aspects. In terms of academic literacy, although the score of Cluster 2 students in the academic knowledge is greater than 4.00, it is lower than other dimensions. The scores on the four sub dimensions of digital literacy are similar and all about 4.5. The scores of social network centrality and social network mode are less than 4.00, and the score of network centrality is the lowest. Cluster 2 students' self-evaluation in academic knowledge, network centrality and social network mode is slightly lower than other dimensions.

Students in Cluster 3 score more than 3.50 on most items. In terms of academic literacy, students in Cluster 3 score the lowest and less than 3.50 in academic knowledge. In the four dimensions of digital literacy, the scores are similar and more than 3.50. In terms of social network, the score in network centrality is the lowest and less than 3.50. The students in Cluster 3 have low self-evaluation on academic knowledge and network centrality.

Students in Cluster 4 score 2.00 - 3.70 in most of the items, but not less than 3.5 in a few items. In terms of academic literacy, the lowest score is 2.44 in academic knowledge. In terms of digital literacy, the score of digital content creation is the lowest (2.95). In terms of social network, the score of network centrality is the lowest (2.61). Cluster 4 students need to improve in all dimensions, especially in academic knowledge, digital content creation and network centrality.

3) The needs and countermeasures of different Clusters in the development of academic literacy

The four Clusters of students have low scores in academic knowledge and network centrality, which indicates that the four Clusters have the need to improve their knowledge mastery and increase social network centrality. In order to improve the knowledge mastery level of undergraduates, the university can offer a series of lectures for them, expand their knowledge vision, and make them understand the position of their majors in the entire academic system. In addition, the school should attach importance to the study of methodology knowledge and set up special scientific research methods courses to systematically teach undergraduates all kinds of research methods and their applicable conditions, so as to lay a theoretical foundation for academic research. In terms of network centrality, undergraduates should actively expand their social networks, cooperate with different students as much as possible. At the same time, undergraduates should strive to seek the central position, occupy the dominant

position of the structural hole through resource control, and improve personal network discourse power, etc. In addition, they can try to build a strong relationship based interpersonal network with the whole class as much as possible in the process of completing academic assignments and conducting classroom discussions, so as to further improve the network structure.

Although Cluster 2 students generally have high scores in all dimensions, they have low score in social network model. When maintaining their excellent performance in other dimensions, they can more actively participate in class activities, contact and interact with friends on social media, etc. Students in Cluster 4 also score low in the dimension of digital content creation, which indicates that students in Cluster 4 have the need to improve their mastery of Internet technology and express themselves in digital content. Cluster 4 students can read Internet related books or take related courses, and record interesting details in daily life through videos, pictures, etc.

4.4. Discussion

Based on the above data analysis, further explanations on the development of undergraduate academic literacy and its influencing factors are as follows.

4.4.1. The Real State of Undergraduate Academic Literacy and Its Influencing Factors

1) Students got a relatively high score in academic ability

Undergraduate students have experienced some scientific research training but not much, so their academic ability still needs to be improved. The measurement score should not be too high, but the score measured in this research is a little high. This may be because the measurement of some items is affected by subjective cognitive bias. The item "I can choose the most appropriate research method for the research questions" (AL13) has a high score, however, the item "I am proficient in at least five research methods in my major and clearly understand the accurate process and requirements of each research method" (AL6) scored very low, which indicates that students' answers to AL13 may be based on the research methods they have mastered, without taking into account other research methods that need to be mastered but not mastered. In addition, we believe that the score of the item "I follow the academic norms and never 'plagiarize' others' articles or achievements in a whole paragraph" (AL16) is too high, which is inconsistent with the actual situation. It is very common for undergraduates to quote the whole paragraph of literature in their course papers or assignments. Other researches show that the scientific research ability of master's students still needs to be improved, which indicates that the self-evaluation score of undergraduate's academic ability in this research is falsely high (Gong, 2022; Duan, 2021).

2) Academic ability has the greatest impact on academic literacy

There is a strong correlation between academic literacy and its sub dimension, especially with academic ability, which shows that academic ability has the

greatest impact on academic literacy. In the constructed structural equation model, the path coefficient between academic ability and academic literacy is the largest, which can also confirm this point. In fact, it is difficult to carry out academic research activities without academic ability. Yuan Jinying believes that academic ability is the key to academic literacy and affects the quality of academic activities (Yuan, 2012).

3) The students with one paper published have the highest scores, which may be affected by subjective cognitive bias

Undergraduates with one paper published have the highest academic literacy scores, followed by students with more than one papers, and students without paper published have the lowest scores. Ideally, students with more than one papers should have higher self-evaluation scores than students with one paper. But this is not the case. In terms of academic knowledge, students with more than one papers scored lower in mastering general knowledge and professional expertise. We believe that students with more than one papers know more about what they do not know, which enables them to evaluate themselves more objectively, so they get a more realistic score, while students with one paper may not be particularly clear about what they do not know. On the contrary, they think that their knowledge level is very high, so they give themselves high marks. The same problem may exist in the measurement of research process design ability and academic normalization.

4) The uneven distribution in demography may bring errors to data analysis

In the overall academic literacy score, males score significantly higher than females. More males have published papers, which is consistent with their higher scores, indicating that the level of academic literacy of male students in the sample is higher than that of female students. In view of the small number of male samples in this research, it is not a good representation of all male students in Beijing Normal University, so the generalization of this conclusion needs to be considered.

On the whole, there is no significant difference in academic literacy among undergraduates in different grades, but the average scores of students in 2019 and 2018 are higher than those in 2021 and 2020. In terms of paper publishing, the higher the grade, the larger the proportion of students who have published papers. This is in line with the conventional experience. Jiang Zhenyu et al. found that junior undergraduates scored significantly lower than senior students in all aspects of the self-assessment of scientific research ability (Jiang & Lu, 2019). This conclusion confirms the conclusion in our research to some extent, but there is still difference. The difference tested in our research is not significant, which may be because the number of students in different grades varies greatly, bringing some errors to the data analysis.

On the whole, there are significant differences in the scores of students in different professional categories, with the highest score for arts and sports students and the lowest score for economics and management students. In terms of paper publishing, the proportion of arts and sports students who have published pa-

pers is the largest, while the proportion of science and engineering students is the smallest. The arts and sports students' self-evaluation scores and the proportion of students with paper published are both high, which may be because the number of arts and sports students in the sample is small, and all of the seven arts and sports students who filled in the questionnaire are very excellent, while the relatively poor students did not actively fill in the questionnaire, causing errors in data analysis. Also, the literature and history students and science and engineering students are in the majority, while there are a small number of economics and management students and arts and sports students in the sample. Therefore, the results of this study have limited responses to the academic literacy of students in economics and management, arts and sports.

5) Social network and digital literacy have a significant positive impact on academic literacy, but some of their sub dimensions have no significant impact on academic literacy

In the regression analysis of digital literacy, social network and academic literacy, we have drawn the conclusion that digital literacy and social network have a significant positive impact on academic literacy. Other researches have also reached a similar conclusion. Huang Yeman et al. found that social networks have a significant positive impact on academic literacy. This conclusion provides support for our research, but their research did not deeply analyze the relationship between social networks and sub dimensions of academic literacy. Yang Jiakun's research found that personal digital literacy has a positive linear impact on personal academic ability, which can also support the conclusion in our research to a certain extent. In addition, Liu Lu found that the digital literacy level of undergraduates can directly affect their scientific research and innovation ability (Liu, 2017). His research measured scientific research and innovation ability through real scientific research operations, such as searching for literature, writing papers, etc. The data measured in this way is very objective and can reflect the real level of research and innovation ability of students. His research provides a good objective level of evidence for our research.

Although digital literacy and social network have a significant impact on academic literacy, some sub dimensions of these two variables have no significant impact on academic literacy. Regression analysis shows that the six dimensions of digital content creation, information and data literacy, problem solving, network centrality, social network model, and network heterogeneity will have a significant positive impact on academic literacy. The three dimensions of network dynamics, network connection strength, communication and collaboration have relatively insignificant effects on academic literacy.

6) Digital literacy has a stronger impact on academic literacy than social networks

The impact of digital literacy on academic literacy is stronger than that of social network, which is mainly reflected in the following aspects. In the regression equation model with digital literacy and social networks as independent variables and academic literacy as dependent variables, the standardization coeffi-

cient of digital literacy is the largest. In the regression equation model with the subdimensions of digital literacy and social network as independent variables and academic literacy as dependent variables, those with large standardization coefficients are the subdimensions of digital literacy. In the structural equation model, the path coefficient of digital literacy affecting academic literacy is greater than that of social network.

4.4.2. Suggestions on Improving Sndergraduate Academic Literacy

The overall score of students on research method knowledge mastery (AL6), human resource acquisition ability (AL7), and technical resource acquisition ability (AL8) is low. Therefore, the school should focus on students' research method knowledge mastery, open professional courses of research methods, and provide students with the necessary human and technical resources to carry out academic activities. Students themselves should also pay attention to the study of research methods and deepen their understanding and application of various research methods.

Schools and teachers should pay attention to the development of digital literacy and social networks when cultivating students' academic literacy. Universities can offer digital literacy related courses and hold relevant competitions. Teachers can encourage students to cooperate and communicate in groups through digital technology and solve professional problems through digital tools in the teaching process. At the same time, the school can relax the policy and encourage students to participate in clubs and competitions across departments, so that students can expand their social networks. Teachers can encourage cross professional cooperation in teaching.

Students themselves should actively seek for the development of digital literacy and social networks, and strive to achieve mutual promotion between them. Students should consciously cultivate their digital skills in the learning process and improve their ability to collect, process and evaluate data. In addition, students should actively participate in club activities, student work and academic competitions, establish contacts with students of different majors and grades, and actively become the center of social interaction, increase the strength of contact with others, so as to obtain more unique and reliable information. In the context of the digital age, a large number of social interactions occur in the digital environment. Therefore, students should learn to use their digital skills to establish and maintain relationships with others, and can also learn more convenient digital operations from others.

5. Conclusion

This research measured the academic literacy level of undergraduates from four dimensions of academic awareness, academic knowledge, academic ability and academic ethics, and also explored two major factors that affect the development of undergraduate academic literacy, namely digital literacy and social networks. This research measured digital literacy from four dimensions of information and

data literacy, communication and collaboration, digital content creation and problem solving, and social network from five dimensions of network centrality, network connection strength, network heterogeneity, network dynamics, and social network mode.

This research has more scientific and statistical significance by means of ANOVA, regression analysis and structural equation test. At present, no research has considered the impact of digital literacy and social networks on academic literacy at the same time. This research links digital literacy and social networks with academic literacy, and further expands and improves existing theories.

Finally, this research still has limitations. First of all, taking the undergraduates of Beijing Normal University as an example, the research conclusions may be difficult to be extended to other levels and types of universities. Secondly, the proportion of men and women and the proportion of grades in the sample are slightly unbalanced, which may bring some errors to the data analysis. Finally, the questions in this research questionnaire are mainly subjective, and the research results are hard to avoid the influence of the subjective factors of the research object.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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