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Promoting the Sustainable Improvement of Educational Empirical Research Quality: What Kinds of Collaborative Production Relationships Make Sense?

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Abstract: With the transformation of the knowledge production model, the research system of educational research is becoming more extensive, and academic collaboration has become an important productive method of promoting the sustainable development of educational empirical research. Given this situation, what kinds of relationships will sustainably improve educational empirical research output quality? Taking the influence of educational empirical research article as an example, we selected 4610 empirical research articles in 15 education journals for analysis, published between the years of 2015 and 2020. In the sustainable development progress of educational empirical research, the optimal scale phenomenon has been verified in cooperative research. Identity collaboration, institutional collaboration, international collaboration, and discipline collaboration were all found to have a strongly significant influence on the sustainable improvement of educational empirical research output quality. Meanwhile, the output quality of educational empirical research is affected by the heterogeneity of the number of cooperators and cooperating identities. These findings suggest that the optimal proportion of teacher–student collaboration should be 2–3, and the optimal scale of colleague collaboration should be 3–4. Compared with teacher–student collaboration, colleague collaboration, including cross-organization and interdisciplinary collaboration, was more conductive to enhancing the sustainable improvement of educational empirical research outcome quality. According to these findings, it is reasonable to believe that, in the process of the sustainable development of educational empirical research, fine-guidance-style teacher–student collaboration and small-scale, cross-unit colleague collaboration should be promoted; meanwhile, strengthening the collaboration between normal universities, optimizing the quality of international collaboration, and promoting pedagogy intersection with other disciplines are also critical to promote the sustainable improvement of educational empirical research outcome quality.

Keywords: empirical education research; sustainable education research; collaborative production relationships; educational empirical research quality; research article influence

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1. Introduction

In the era of big science, scientific research is now characterized by large investments, multidisciplinary integration, and ambitious research goals [1,2]. With the transformation of the knowledge production model, the traditional individual scientific research pattern cannot gradually produce sustainable high-level research outputs [3,4]. From individual research, the method of producing scientific research is gradually transitioning to team collaboration. Academic collaboration has become the mainstream method of scientific production [5,6]. In order to realize a sustainable development of disciplines, obtain wider research foundations and equipment, and extend the academic network, most scholars tend to collaborate with others within or across disciplines. This behavior is reflected not only in the fields of science and engineering but also in the humanities and social sciences [7].

In recent years, evidence-based educational empirical research has received considerable attention from around the world. The development of educational empirical research usually predicts the sustainable improvement of educational discipline quality [8]. Empirical research emphasizes obtaining scientific data through the application of the scientific method and acceptance of scientific tests [8]. Compared to individual research, sustainable collaborative research is more efficient for conducting empirical research [9]. According to the current research, most of the articles' output from educational empirical research are completed through institutional collaboration [10]. Academic collaboration has become a significant productive mode of promoting the sustainable development of educational empirical research. Collaborative production relationships have the capacity to reflect the cooperative attributive relationships and laws among the participating subjects in the scientific research process [11]. Nowadays, these types of relationships mainly refer to collaboration among scholars, institutions, and districts. However, not all of the collaborative production relationships are sustainable and efficient for improving scientific research output quality. Different cooperative production relationships will produce different research performances [12]. From the perspective of scientometrics, research on the relationship between scientific research collaboration and output performance mainly concentrates on medicine, biology, psychology, informatics, etc. [13–16]; however, a small number of studies have been conducted in the field of educational studies or even in the educational empirical research area. Therefore, the exploration of how collaborative production relationships within educational empirical research affect the educational empirical research output quality has become an urgent topic that is supposed to promote the sustainable development of educational empirical research. Based on this context, this research explored several questions as follows:

RQ1. What kinds of collaborative production relationships exist in China?

RQ2. What kind of collaborative production relationship would be helpful to sustainably improve the educational empirical research output quality?

RQ3. Is there heterogeneity in the effect of collaborative production relationships on the sustainable improvement of educational empirical research output quality?

This research topic is critically important to the educational research occurring in the transition period of the research pattern and knowledge production model. The findings of such an exploration not only help to deepen the understanding of the relationships between scientific research collaboration and the sustainable improvement of educational empirical research output quality from an academic level but also provide the necessary scientific basis for the sustainable development of the educational discipline in the future from a practical perspective.

2. Literature Review and Research Hypothesis

2.1. Scientific Research Collaboration and the Sustainable Improvement of Educational Empirical Research Output Quality

In recent decades, a large amount of research has linked academic collaboration with educational empirical research output quality, and it is generally thought that scientific research collaboration has a positive impact on the sustainable improvement of educational empirical research output quality [17]. A study published in *Nature* analyzed 25 million articles from 1981 to 2012 included in the WOS database, finding that most of these high-quality academic research articles were produced by collaborations [18]. Through conducting research on collaborative academic research articles after the 17th century, Beaver and Rosen [19] demonstrated that the scientists who held a collaborative attitude had better conditions for academic research production; they also found that the sense of collaboration can positively predict increases in the scope and fame of the scientists. Zhu et al. [20] conducted a case study on a university in China and found that collaborative research articles usually had a significantly higher citation frequency than individual articles. Lv [21] conducted an analysis to explore the application of the quantitative research

method in Chinese educational empirical research and suggested that the major research institutions usually obtain more prominent results through networking.

A consensus has been reached in the academic field that scientific research collaboration predicts the sustainable improvement of educational empirical research output quality; however, the specific mechanism and extent of the effect of the number of collaborators on the sustainable improvement of educational empirical research output quality are still controversial [22]. Some scholars have suggested that the number of collaborators has a positive relationship with educational empirical research output quality [23]. For example, through analyzing articles in the field of cancer, Lawani [24] demonstrated that increasing the number of participants in the project increased the proportion of high-quality publications, whereas the proportion of total self-citations decreases. Chen and Sun [25] considered a physicist and their scientific research team as a case study to explore the relationship between the number of authors and their article citations; the results showed a positive correlation. However, other scholars believe that the number of collaborators and the sustainable improvement of educational empirical research output quality cannot simply be attributed to a correlation or a linear relationship: instead, there is an optimal scale phenomenon. Franceschet and Costantini [26] divided collaborators into groups of three people and divided the quality of the articles into four grades according to the frequency of citations in the overall sample. The results showed that small-scale collaborations were more effective. By analyzing the data of several disciplines in the WOS database, Liu [27] obtained the density distribution curve of the relationship between collaboration scale and the quantity of research articles. Liu found the existence of an optimal phenomenon of scientific collaboration as well. Based on this point of view, Yang and Li [28] analyzed the data from the *JCR* journal and found that the scale of collaboration cannot be expanded indefinitely: the best collaboration scale was found to be 2–4. In summary, we suggest a hypothesis that scientific collaboration has the ability to promote the sustainable improvement of educational empirical research output quality. However, in terms of the disciplinary nature of educational research, there are heterogeneity and thresholds in the impact of scientific research collaboration on educational empirical research output quality. The hypotheses are as follows:

Hypothesis 1 (H1). *Scientific research collaboration has a positive effect on the sustainable improvement of educational empirical research output quality.*

Hypothesis 2 (H2). *The number of collaborators may have a significant, inverted U-shaped influence on educational empirical research output quality.*

2.2. Collaborative Production Relationships and the Sustainable Improvement of Educational Empirical Research Output Quality

Collaborative production relationships are essential to the sustainable improvement of educational empirical research output quality and are embodied in aspects of identity, institution, region, and discipline [29,30].

Collaborative identity mainly refers to teacher–student, colleague, and student collaboration relationships [31]. Among them, teacher–student collaboration is the main collaborative type of relationship in scientific research [32]. One study divided the student–teacher collaboration into "teacher ahead and student behind" (teacher as the first author) and "student ahead and teacher behind" (student as the first author) according to the authorship order; this suggested that the "student ahead and teacher behind" mode is the main style of teacher–student collaboration, accounting for 80% of all teacher–student collaborative articles [33]. In the research on collaborative identity and the sustainable improvement of educational empirical research output quality, Zuckerman [34] explored the data of 92 American scholars who won the Nobel Prize before 1972 and found that more than half of the winners were former Nobel Prize winners', students or postdoctoral associates. AlShebli et al. [35] conducted a bibliometric analysis of 215 million research articles published before the year 2020 and found that teacher–student collaboration can positively

predict a higher academic influence of the students. Further examining the relationship between authorship order and the influence of scientific research articles, Xie et al. [36] used authorship order as one of the important index parameters to evaluate the influence of the authors, finding that the authorship order can affect the influence of the authors and their research articles. However, many different findings have been voiced. For instance, Mccann and Meg [37] explored the collaboration characteristics of team heads and their impact on scientific research production and found that authorship order has no significant influence on scientific research production. This means that the authorship order in the collaborative identity relationship may have effects on the sustainable improvement of educational empirical research output quality. Therefore, we constructed a new hypothesis:

Hypothesis 3 (H3). *Compared with student–student collaboration, colleague collaboration and teacher–student collaboration are more conducive to enhancing the sustainable improvement of educational empirical research output quality.*

The relationships of institutions can be divided into school–school, school–enterprise, and government–school collaboration, etc., from the perspective of different types of institutions [38–40]. They can also be divided into within-institutional and cross-institutional collaboration from the perspective of institutional span [41]. In the research on the relationship between collaborative institutions and the sustainable improvement of educational empirical research output quality, Abramo et al. [42] reported that, compared to single-institution collaboration, the output of cross-institutional collaboration in Italian universities from 2001 to 2003 was published in journals with higher impact factors on average. In China, Ling et al. [43] found that school–enterprise cooperation had a significant positive effect on scientific research output. Moreover, Liu and Shao [32] conducted a descriptive statistical analysis of research articles published in 18 educational journals and found that, in the field of higher education research compared to other authors in same-level units, the authors in the same faculty had a higher cooperative output. In cross-level units, compared to school–enterprise cooperation, school–school cooperation was found to have a higher output. However, this research did not reveal the relationship between the type of cooperative organization, the span of the organization, and the influence of higher education research articles. Therefore, we suggest other hypotheses:

Hypothesis 4 (H4). *Different types of institutional collaboration will affect the sustainable development of educational empirical research output quality. Compared with other kinds of institutional collaboration, collaborations among normal universities have more positive effects on the sustainable improvement of educational empirical research output quality.*

Hypothesis 5 (H5). *Compared with same-institution collaboration, cross-institution collaboration may have more positive effects on the sustainable improvement of educational empirical research output quality.*

The region of collaboration can be mainly divided into intra-city, cross-city, and international collaboration [44]. Some of the studies divided regional collaboration into international and domestic collaboration [45,46]. Proximity theory provides the framework to explain the occurrence of intra- and cross-city collaboration [47]. Geographical proximity considerably increases the frequency of face-to-face interaction and the efficiency of information exchange between scientific research collaboration institutions, thereby improving the quality of collaborative articles [48]. Most of the research focused on the relationships between international collaboration and outputs of scientific research [49,50]. Barjak and Robinson [51] reported that international collaboration has a positive impact on the output and quality of scientific research articles by EU research teams. Moreover, based on the data on published research articles from the top 110 universities in the USA, Adams et al. [52] found that international collaboration has a significant positive impact on the citation frequency of the research article; however, a negative correlation was found with scien-

tific productivity. In China, He and Li [53] analyzed the data of State Key Laboratory research articles published between 2005 and 2014. The result showed that international collaboration is an important factor for improving the journal level in which the article is published; however, the impact on the frequency of citations is not significant. This means international collaboration may have effects on the sustainable improvement of educational empirical research output quality. Based on these findings, we propose:

Hypothesis 6 (H6). *Compared with domestic collaboration, international collaboration may have more positive effects on the sustainable improvement of educational empirical research output quality.*

In collaborative disciplines, the main categories are based on colleagues and departments [54], whereas research majors and directions have been regarded as the basis to identify if the collaboration is cross-discipline [55]. The analysis of the relationship between cross-disciplinary degrees and the sustainable improvement of educational empirical research output quality is one of the important contents of cross-discipline research; this kind of relationship has been reported differently in various studies [56]. Steele and Stier [57] claimed that the stronger the cross-discipline degree of the article, the larger the number of citations. Larivière and Gingras [58] found that high degrees of disciplinary and cross-discipline research articles have little influence. Li et al. [59] indicated that no correlation necessarily exists between cross-disciplinary collaboration and cross-disciplinary citation preference and article influence. Some scholars found an inverted U-shaped relationship between the degree of cross-disciplinary research and the quality of the research article [53]. In the field of educational research, Ma and Yao [55] analyzed the core authors from 2015 to 2019 and suggested that cross-disciplinary research helps improve the output of educational empirical research; however, their findings did not reveal the relationship between cross-disciplinary collaboration and the influence of the research article. In summary, disciplinary interactive collaboration may have effects on the sustainable improvement of educational empirical research output quality. Therefore, we proposed a hypothesis:

Hypothesis 7 (H7). *Compared with within-discipline collaboration, cross-discipline collaboration and other disciplinary interactive collaboration may have more positive effects on the sustainable improvement of educational empirical research output quality.*

3. Methodology

3.1. Key Concepts

3.1.1. Educational Empirical Research

As a research paradigm, the development of empirical research can be summarized into three stages: classical positivism, logical positivism, and post-positivism [60]. Along with the evolution of positivist methodology, educational empirical research has experienced three stages, including the purely quantitative stage, the quantitative-based stage, and the coexisting stage of quantitative and qualitative [61]. Meanwhile, the academy also debated the connotation of educational empirical research [62,63]. Based on the point view of post-positivist methodology, in this research, we believe that educational empirical research is used to analyze and interpret collected data or information through experiments on, and observations, interviews, or surveys of, research subjects. This is a research paradigm that usually discusses the development law of issues based on evidence of facts and tries to solve problems related to education [10]. Educational quantitative research, educational qualitative research, and educational mixed research methods are all included in the range of educational empirical research. The development of educational empirical research benefits the sustainable improvement of educational empirical research output quality.

3.1.2. Collaborative Production Relationships

Scientific research production is generally regarded as the working process of scientific knowledge production. Scientists create and produce knowledge through this process [64]. In general, the two types of scientific research production are individual production and collaborative production [65]. Collaborative production, which is also called scientific research collaboration, is regarded as one of the most important ways to promote the sustainable production of scientific research. Werner suggested that collaborative production is a research behavior in which researchers cooperate based on common research purposes, exchange information and communicate with each other, and fully realize the complementarity of resources or capabilities among individuals. Collaborative production relationships are recognized as having the capacity to reflect collaborative relationships and the law of collaborative attributes in the process of scientific research [11]. In the era of big science, the three main collaborative production relationships are collaborations among authors, institutions, and different regions. Considering the identity of the authors and their subject background, collaborative production relationships can be categorized into teacher–student, colleague, student–student, and cross-discipline collaboration [66]. In this research, we explored collaborative production relationships from the perspective of author scale, identity, institution, region, discipline, etc.

3.1.3. Scientific Research Output Quality

Scientific research output is an important product of collaborative production. The scientific research output is usually presented by articles, monographs and research reports, etc. The quality of scientific research output is an important indicator of the research capabilities of both scientific research institutions and individual researchers [52]. The research output in this article is reflected by "article influence". Current studies measure the influence of articles in terms of the frequency of citations, the number of downloads, h-index, g-index, etc. [67–69]. Among these indicators, the number of downloads is the direct production of publishing digitization, which records the number of times an article has been saved and downloaded from a journal website or publisher [70]. The cited frequency index directly reflects the knowledge diffusion of academic articles [71]. The number of downloads and the frequency of citations are the basic indices that are widely used to evaluate the influence of articles. These two indicators have their own emphases and are related to each other; a moderate degree of correlation exists between the two indices [72]. In this paper, the quality of scientific research output refers to the influence of articles produced in the field of educational empirical research, which was mainly measured by two indicators, the number of downloads and the citation frequency, in order to examine the internal connection between collaborative production relationships and the sustainable improvement of educational empirical research output quality. The indicators of downloads and citations are affected by the year of publication. For example, articles published in 2015 must have higher downloads and citations than articles published in 2019, generally. Therefore, the method of year fixed effect was used to solve this problem. The variable of the year was treated as a dummy variable in the model. This method can control the impact of the publication year, which means that the model can analyze how the independent variables affect dependent variables separately.

3.2. Sample Selection

We selected educational journals in the database of the 2021–2022 Chinese Social Science Citation Index (CSSCI) as the reference range; comprehensively considered journal positioning, impact factors, and other factors; and selected 15 representative academic journals, including: *Peking University Education Review*, *Education Development Research*, *Comparative Education Review*, *Fudan Education Forum*, *Journal of Higher Education*, *Journal of Educational Science of Hunan Normal University*, *Journal of East China Normal University (Educational Sciences)*, *Education Research*, *Journal of Educational Studies*, *Educational Research*, *Curriculum*, *Teaching and Method*, *Educational Research and Experiment*, *Tsinghua Journal of*

Education, *Journal of Studies in Early Childhood Education*, and *Journal of the Chinese Society of Education*. The bibliographic data and full text PDF of 12,530 academic articles published in the 15 sample journals from 2015 to 2020 were downloaded from CNKI. Taking the abstract in the bibliographic data as the information source and using the empirical research literature search keyword package conducted by Zhu and Ma [10] as the search term, 4610 educational empirical research studies were selected as the sample for this research.

3.3. Coding and Model Construction

After selecting the sample for this research, the author information of the selected articles was coded as shown in Table 1.

Table 1. Variables and the coding method.

Variable Category	Variable	Abbreviation	Type of Variable	Definition and Coding
Explanatory Variable	Scientific Research Collaboration	CO	Categorical Variable	0, No; 1, Yes.
	Number of Collaborators	CN	Continuous Variable	The number of collaboration participants.
	Collaborative Identity	CID	Categorical Variable	0, Student–student collaboration; 1, Colleague collaboration; 2, Teacher–student collaboration.
	Teacher–Student Authorship	CSI	Categorical Variable	0, Teacher ahead and student behind; 1, Student ahead and teacher behind.
	Type of Collaborative Institutions	CIT	Categorical Variable	0, Normal university with normal university; 1, Normal university with comprehensive university; 2, Comprehensive university with comprehensive university; 3, Mixed institutions.
	Collaborative Institutions Span	CIG	Categorical Variable	0, Within-department; 1, Cross-department; 2, Cross-university units.
	International Collaboration	CIN	Categorical Variable	0, No; 1, Yes.
	Discipline Collaboration	CSU	Categorical Variable	0, Within-disciplinary intersection relationship; 1, Cross-disciplinary intersection relationship; 2, Other disciplinary interaction relationship.
Dependent Variable	Scientific Research Output Quality	IN	Continuous Variable	Weighted composite index of the citation frequency and downloads.
Control Variable	Year of Publication	YR	Continuous Variable	The year the article was published.
	Research Foundation	FD	Categorical Variable	0, No; 1, Yes.
	Title of First Author	FP	Ordinal Variable	1, Graduate students; 2, Middle level; 3, Associate professor; 4, Professor.
	Institution of First Author	FI	Categorical Variable	0, Directly affiliated normal university; 1, Local normal universities; 2, Local comprehensive universities; 3, China 9; 4, Overseas colleges and universities; 5, Other institutions.
	Impact Factor of Journal	JIF	Continuous Variable	Impact factor of published journals (in 2020).

The second variable was the scientific research output quality, represented by article influence (IN), which was the dependent variable in this study. In the analysis process, we normalized two variables, citation frequency and number of downloads to obtain the G citation frequency and G download values. Considering the differences between various journals, data on the downloads and citations of the sample articles all came from the CNKI website (https://www.cnki.net/ 20 February 2022). The downloads and citation frequencies of sample articles were collected from two periods, including 10 to 15 July 2021 and 19 to 20 February 2022. Since the two periods are very close, the search errors caused by downloads and citations can be ignored. Afterwards, experts were invited to examine the weight coefficients of these two indicators. Followed by this procedure, the two indicators' weight coefficients were discussed by the experts. According to the interviews conducted with 27 experts in the field of educational empirical research, the weight coefficients of citations and downloads were suggested. Through adding and averaging the values the experts suggested, we obtained the weight coefficients of citations and downloads, which were 0.7 and 0.3, respectively. Meanwhile, we invited the experts to discuss the reason for the weight coefficient differences. Interviews with experts were as follows:

> *In the Chinese context, compared with the number of downloads, the citation frequency of an article can reflect the article influence more effectively, so it is given a higher weight. The reason to give this statement is complicated. The downloads of Chinese articles are strongly disturbed by research hot spots, and if the topic of this research is novel enough and conforms to the national education policy, the articles will have a lot of downloads; however, it can explain the article influence partially. The readers will only cite the articles when they think it is valuable. Therefore, citation frequency can truly reflect the influence of the research articles. (7 August 2021, Expert 3)*

> *The number of downloads is usually affected by journals, topics, author identity, and other related elements. There is no doubt that the number of downloads can represent the influence of part of the articles, but I believe citation frequency is more important. It cannot be denied that only the high-quality and high-influence articles will have higher citation frequency. According to my experience, the citation frequency should account for 70%, and the number of downloads should account for 30% when judging if the article has high influence. So, I would like to suggest that the weight of citation frequency and the number of downloads should be 7:3. (7 August 2021, Expert 5)*

The specific weighting was as follows: article influence score = (0.7 × G citation frequency + 0.3 × G number of downloads) × 1000; the higher the score, the stronger the influence of the article.

The third group of variables was the control variables, which were the factors that affect the influence of research articles. In addition to the collaborative production relationships, which were our focus in this study, there are other factors, such as the author's title, journal impact factor, funding support of projects, and research field [73,74]. Thus, the year of publication (YR), research funding (FD), title of first author (FP), institution of first author (FI), and journal impact factor (JCR) were included in the model as control variables. The first author's title was categorized into graduate student, middle-level class, associate professor, and professor. The institution of first author was categorized as directly affiliated normal universities, local normal universities, the China 9 school alliance (C9), local comprehensive universities, overseas colleges and universities, and other institutions. Directly affiliated normal universities refer to Beijing Normal University, East China Normal University, Northeast Normal University, Southwestern University, Central China Normal University, and Shaanxi Normal University. Local normal-level universities refer to other normal colleges and universities other than directly affiliated normal schools. The C9 School Alliance refers to Peking University, Tsinghua University, Zhejiang University, Shanghai Jiaotong University, Fudan University, Nanjing University, Harbin Institute of Technology, Xi'an Jiaotong University, and University of Science and Technology of China. The local comprehensive universities refer to other comprehensive

colleges except for the C9 School Alliance. Overseas colleges and universities refer to all colleges and universities outside of mainland China, and other institutions refer to research institutes, primary and secondary schools, administrative departments, etc.

The measurement model in this study was designed as follows:

$$\begin{aligned} Y_i = {} & \beta_0 + \beta_1 cooperation_i + \beta_2 number_i + \beta_3 identity_i + \beta_4 institution_i \\ & + \beta_5 internation_i + \beta_6 subject_i + \gamma X_i + \delta_1 university_i + \delta_2 year_i + \varepsilon_i \end{aligned} \quad (1)$$

where Y_i represents the influence of research article i, $cooperation_i$ indicates scientific collaboration, $number_i$ refers to the number of collaboration participants, $identity_i$ refers to the identity of the collaborators (including teacher and student authorship), $institution_i$ represents collaboration institutions (including type and span of institutions), $internation_i$ represents international collaboration, and $subject_i$ refers to disciplinary collaboration. The variable X_i refers to various control variables, including research funding, first author institution, title of first author, and journal impact factor; $university_i$ is the fixed effect of the institution type; $year_i$ refers to the fixed effect of publication time; ε_i is the random disturbance term; and β_0 represents the intercept term.

Since we investigated the existence of a nonlinear relationship between the number of coauthors and the influence of educational empirical research articles, we established Model (2) based on Model (1):

$$\begin{aligned} Y_i = {} & \beta_0 + \beta_1 cooperation_i + \beta_2 number_i + \beta_3 number^2{}_i + \beta_4 identity_i + \beta_5 institution_i \\ & + \beta_6 internation_i + \beta_7 subject_i + \gamma X_i + \delta_1 university_i + \delta_2 year_i + \varepsilon_i \end{aligned} \quad (2)$$

where $number^2$ refers to the quadratic term of the number of coauthors, and the other variables remain unchanged. If β_2 is positive, β_3 is negative, and β_2 passes the significance test in the data analysis; this indicates an inverted U-shaped relationship between the number of coauthors and the influence of the educational empirical research article. When the number of coauthors reaches $-\beta_2/(2\beta_3)$, the influence of the article reaches the theoretical optimum effect.

Since the article influence variable in this study was a non-negative discrete random variable and the data did not conform to a positive distribution, the empirical analysis of this type of problem with the OLS regression model has certain theoretical flaws. For this reason, we adopted a Poisson regression to analyze the dependent variable [75]. The model was estimated through the log-likelihood function method. The Poisson regression coefficient is interpreted as a change in the 1 unit in the independent variable under the control of other variables, which produces a change in the logarithmic mean of the dependent variable. What the finding explains is not the mean value of the logarithm but the expected value (rate).

4. Findings

According to the research design, we analyzed the differences between the influence of different collaborative production relationships in education empirical research, the influence of collaborative production relationships on the sustainable improvement of research output quality, and their heterogeneity. The research findings are described below.

4.1. The Characteristic Trend Distribution of Sustainable Development of Educational Empirical Research and its Collaborative Production Mode

The overall sample data show that the proportion of educational empirical research articles in the total number of articles in China continues to grow, and educational empirical research is maintaining a sustainable development trend and is more accepted and adopted, as shown in Figure 1. The total number of empirical research articles in the sample journals from 2015 to 2020 was 4210, accounting for 36.8% of the total number of articles. The annual publication in the sample journals dropped from 2233 in 2015 to 2045 in 2020; however, the

annual empirical research publication maintained a steady growth from 34.4% to 39.2% in 2020.

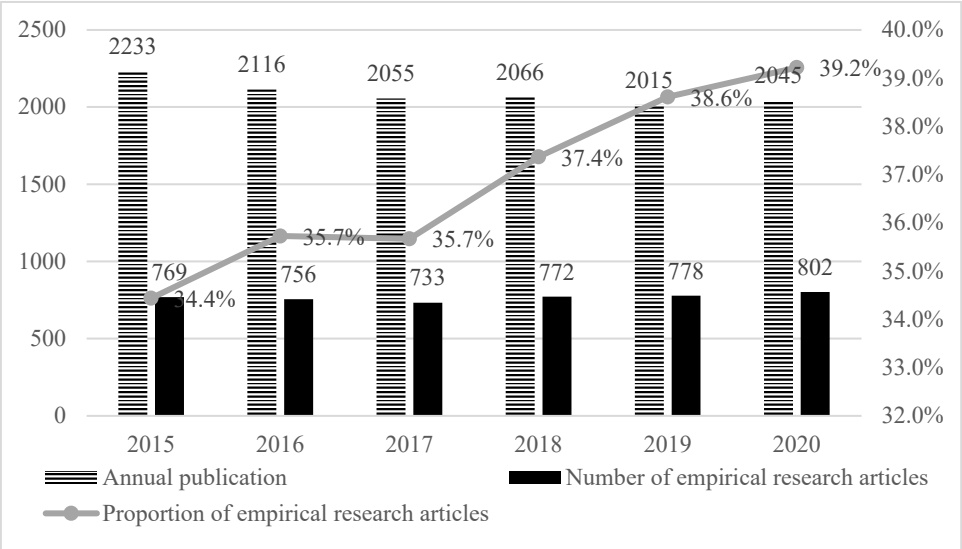

Figure 1. Educational empirical research sustainable development trend map in China. Data resource: Educational empirical research in 15 sample journals.

Collaborative research has become common in sustainable educational empirical research. Most of the collaborative research consisted of teacher–student collaboration, same-type university collaboration, cooperation with second-level units, and interdisciplinary cooperation, as shown in Table 2.

Table 2. The characteristic trend distribution of cooperative production relations in the sustainable development progress of educational empirical research.

Collaborative Production Relationship		2015	2016	2017	2018	2019	2020	Total 6-Year
Research Collaboration	No	36.4%	34.9%	33.4%	30.7%	30.1%	27.9%	32.2%
	Yes	63.6%	65.1%	66.6%	69.3%	69.9%	72.1%	67.8%
Collaborative Identity	Teacher–student collaboration	62.4%	61.2%	60.2%	62.2%	62.1%	58.8%	61.1%
	Colleague collaboration	36.8%	37.2%	38.5%	36.4%	36.9%	39.6%	37.6%
	Student collaboration	0.8%	1.6%	1.2%	1.3%	0.9%	1.6%	1.2%
Teacher–Student Authorship	Teacher ahead and student behind	62.0%	65.8%	65.6%	65.2%	66.3%	67.1%	65.4%
	Student ahead and teacher behind	38.0%	34.2%	34.4%	34.8%	33.7%	32.9%	34.6%
Type of Collaborative Institution	Normal university with normal university	33.3%	33.1%	30.9%	36.8%	38.2%	38.8%	35.4%
	Normal university with comprehensive university	11.0%	10.0%	10.5%	11.6%	11.9%	11.6%	11.1%
	Comprehensive university with comprehensive university	37.0%	39.4%	38.7%	33.1%	30.5%	28.7%	34.3%
	Mixed institutions	18.6%	17.5%	19.9%	18.5%	19.3%	20.9%	19.2%
Collaborative Institutions Span	Within-department	46.4%	44.3%	45.9%	46.5%	43.6%	40.5%	44.4%
	Cross-department	10.8%	12.0%	12.5%	13.5%	12.3%	13.8%	12.5%
	Cross-university units	42.7%	43.7%	41.6%	40.0%	44.1%	45.7%	43.0%
International Collaboration	No	94.7%	94.9%	95.3%	94.8%	94.3%	92.6%	94.4%
	Yes	5.3%	5.1%	4.7%	5.2%	5.7%	7.4%	5.6%
Discipline Collaboration	Within-disciplinary intersection	66.1%	64.2%	68.2%	71.2%	70.0%	68.9%	68.2%
	Cross-disciplinary intersection	16.2%	19.5%	16.6%	17.8%	17.6%	17.6%	17.6%
	Other disciplinary interaction	17.8%	16.3%	15.2%	11.0%	12.3%	13.5%	14.2%

Data resource: Educational empirical research in 15 sample journals.

In terms of scientific research collaboration, we found 3126 collaborative research articles (accounting for 67.8%) and 1484 single-author research articles (accounting for 32.3%), indicating that collaborative research has become the dominant production relationship in educational empirical research. Through a deeper exploration of the different collaborative production relationships, we found 1911 collaborative articles written by teachers and students (accounting for 61.1%) in collaboration, 1176 collaborative articles with colleagues (accounting for 37.6%), and only 39 collaborative articles produced by student collaboration (accounting for 1.2%). Among the teacher–student collaborative articles, the teacher ahead and student behind collaboration model produced 587 more articles than the student ahead and teacher behind collaboration model. This demonstrated that, in terms of the collaborative identity of sustainable educational empirical research, teacher–student collaboration, especially the teacher ahead and student behind collaborative model, was the dominant relationship, followed by cooperation with colleagues. In terms of the types of collaborative institutions, normal school collaboration and comprehensive school collaboration were found to produce more articles: 1106 (accounting for 35.4%) and 1073 (accounting for 34.3%), respectively. In terms of the span of collaborative institutions, cross-departmental collaboration had the strongest capacity to produce articles with a total article number of 1345 (accounting for 43.0%), followed by cross-university collaboration with 1389 papers (accounting for 44.4%). This result indicates that most of the collaborative institutions were universities of the same type, and the units were at the same level. As for international collaboration, the number of cooperative publications was low, at only 176 (accounting for 5.6%), indicating that educational empirical research in China is still dominated by domestic collaboration. From the perspective of disciplinary collaboration, the proportion of the intradisciplinary cooperative article was the highest, reaching 2132 articles (accounting for 68.2%) in total, and only 549 and 445 cross-disciplinary (accounting for 17.6%) and other-disciplinary (accounting for 14.2%) interactive articles were found, respectively, indicating that the diversity of disciplines in the field of empirical education research in China is poor, and interdisciplinary collaboration holds a leading position.

From the perspective of annual trends, in terms of scientific research collaboration, the proportion of independent research papers has decreased yearly, from 36.4% in 2015 to 27.9% in 2020; the proportion of collaborative research papers has increased steadily, from 63.6% in 2015 to 72.1% in 2020, an increase of 8.5%. As for teacher and student authorship, the proportion of "teacher ahead and student behind" collaborative research articles showed a fluctuating upward trend, from 62.0% in 2015 to 67.1% in 2020; however, "student ahead and teacher behind" collaborative research has fallen by roughly 5.1% in the last six years. In terms of collaborative institution type, the collaborative research articles conducted among normal universities showed a fluctuating upward trend, from 33.3% in 2015 to 38.8 in 2020. As for collaborative institution span, the proportion of research articles written by collaboration from same department has dropped by 5.9% in the past six years, while the proportion of articles from the collaboration of cross institutions has relatively increased. The indicators of collaborative identity, international collaboration and discipline collaboration experienced no significant changes in the past six years. Annual data present that collaborative research has a continuous increase in the sustainable development progress of educational empirical research. Teacher–student collaboration with the mode of "teacher ahead and student behind" presents a continuous and overwhelming advantage. The collaboration tendency of "cross-institution" is more clear, and the collaboration tendency of "within-disciplinary intersection" is more clear in discipline collaboration.

4.2. Differences in Scientific Research Output with Different Collaborative Production Relationships in the Sustainable Development Progress in Educational Empirical Research

We found significant differences in educational empirical research output quality (article influence) from the perspectives of scientific research collaboration, types of collaborative institutions, and international collaboration, as shown in Table 3.

Table 3. The differences in the distribution of scientific research output quality in the different collaborative production relationships in sustainable progress of educational empirical research.

Collaboration Production Relationships		*N*	Scientific Research Output Quality (Article Influence)	
			M ± SD	**t/F**
Scientific Research Collaboration	No	1484	37.27 [b] ± 47.12	5.213 ***
	Yes	3126	46.31 [a] ± 49.92	
Collaborative Identity	Teacher–student collaboration	1911	45.12 ± 43.57	0.715
	Colleague collaboration	1176	46.33 ± 61.13	
	Student collaboration	39	37.65 ± 31.25	
Teacher–Student Authorship	Teacher ahead and student behind	1249	42.32 ± 43.58	0.123
	Student ahead and teacher behind	662	45.74 ± 46.25	
Type of Collaborative Institution	Normal university with normal university	1106	53.11 [a] ± 63.72	9.258 ***
	Normal university with comprehensive university	348	40.11 [c] ± 35.44	
	Comprehensive university with comprehensive university	1073	40.58 [c] ± 35.11	
	Mixed institutions	599	49.11 [b] ± 59.78	
Collaborative Institutions Span	Within-department	1389	46.71 ± 48.57	0.712
	Cross-department	392	49.12 ± 64.59	
	Cross-university units	1345	46.32 ± 51.33	
International Collaboration	No	2950	46.58 [a] ± 52.72	6.874 ***
	Yes	176	35.12 [b] ± 35.87	
Discipline Collaboration	Within-disciplinary intersection	2132	45.12 ± 44.97	1.558
	Cross-disciplinary intersection	549	49.11 ± 76.58	
	Other disciplinary interaction	445	46.44 ± 48.53	

*** $p < 0.001$. a–c The results of multiple comparisons: if the letter is the same, there was no significant difference among the average scores; if the letters are different, there were significant differences. The average scores are arranged from large to small: a > b > c.

In scientific research collaboration, the score of the educational empirical collaborative research influence was 46.31, which was significantly higher than that of independent research articles. This indicates that collaboratively published educational empirical research articles have a higher influence than those produced from independent research. From the perspective of collaborative institutions, the influence of the normal university–normal university collaborative articles achieved the highest score (53.11), followed by mixed institutional collaborative articles (49.11). The last two in terms of the influence of their articles were the models of normal university–comprehensive university collaboration and comprehensive university–comprehensive university collaboration. This finding indicates that the educational empirical collaborative articles conducted among normal universities are more influential than those produced by the rest of the institutions. In terms of international collaboration, the score of domestic collaborative articles was 46.58, which was significantly higher than that of international collaborative articles. We found that international collaborative research articles' influence was not as high as expected. Moreover, we found no significant difference in terms of collaborative identity, teacher–student authorship, collaborative institution span, and disciplinary collaboration. However, from the statistical data, we found that the influence of colleague collaborative articles (46.33) in the dimension of collaborative identity, student ahead and teacher behind collaborative articles (42.32) in the dimension of teacher–student authorship, cross-department collaborative articles (49.12) in the dimension of collaborative institution span, and cross-disciplinary collaborative articles (49.11) in the dimension of disciplinary collaboration had strong impacts.

4.3. Regression Analysis of the Influence of Collaborative Production Relationships on Educational Empirical Research Outputs in the Sustainable Development Progress of Educational Empirical Research

According to the analysis, we found significant differences in the scientific research output quality produced by various collaborative production relationships; however, we found that it was affected by factors such as publication year and journal influence factors. Therefore, it was necessary to construct a regression model of collaborative production relationships on the influence of the research articles as shown in Table 4.

Table 4. Poisson regression model results of the collaborative production relationships on research article output quality (article influence).

	Predictor Variable	**Scientific Research Output Quality (Article Influence)**			
		Model 1	**Model 2**	**Model 3**	**Model 4**
	Intercept	3.205 *** (0.012)	3.311 *** (0.034)	3.291 *** (0.034)	2.894 *** (0.047)
Explanatory Variables	Scientific research collaboration	0.135 *** (0.051)	-	-	-
	Number of coauthors	-	0.059 *** (0.003)	0.081 *** (0.005)	0.151 *** (0.023)
	Quadratic term of the number of coauthors	-	-	-0.014 *** (0.004)	−0.026 *** (0.004)
	Colleague collaboration	-	0.221 *** (0.029)	0.217 *** (0.031)	-
	Teacher–student collaboration	-	0.159 *** (0.034)	0.161 *** (0.032)	-
	Student ahead and teacher behind	-	-	-	0.416 *** (0.020)
	Normal U–comprehensive U	-	−0.231 *** (0.015)	−0.221 *** (0.013)	−0.271 *** (0.023)
	Comprehensive U–comprehensive U	-	−0.161 *** (0.015)	−0.163 *** (0.014)	−0.114 *** (0.022)
	Mixed institutions	-	−0.091 *** (0.014)	−0.091 *** (0.012)	−0.179 *** (0.018)
	Cross-department	-	−0.015 (0.010)	−0.014 (0.012)	−0.036 ** (0.011)
	Cross-university	-	0.039 *** (0.010)	0.037 *** (0.009)	−0.006 (0.012)
	International collaboration	-	−0.093 *** (0.014)	−0.094 *** (0.014)	0.034 (0.025)
	Cross-discipline	-	0.084 *** (0.010)	0.081 *** (0.008)	0.035 ** (0.013)
	Other discipline	-	0.047 *** (0.009)	0.043 *** (0.007)	0.081 *** (0.011)
Control Variables	Research funding	0.051 *** (0.007)	0.032 *** (0.008)	0.031 *** (0.008)	0.049 *** (0.011)
	Title of first author	0.023 *** (0.002)	0.002 (0.002)	0.001 (0.002)	0.142 *** (0.004)
	Journal impact factor	0.211 *** (0.002)	0.189 *** (0.002)	0.184 *** (0.003)	0.158 *** (0.003)
Fixed Effect of Institution Type		Yes	Yes	Yes	Yes
Fixed Effect of Publication Time		Yes	Yes	Yes	Yes
Log Likelihood		−71,238.691	−48,756.113	−422,531.692	−25,718.112
N		4610	3126	3126	1911

** $p < 0.01$; *** $p < 0.001$. Student–student collaboration was the reference group in collaborative identity, teacher ahead and student behind was the reference group in teacher–student authorship, normal university–normal university was the reference group in the type of collaborative institutions, within-department was the reference group of institution collaboration span, domestic collaboration was the reference group in international collaboration, within-disciplinary interaction was the reference group in discipline collaboration, without funding was the reference group in research funding, and graduate students were the reference group for the title of first author. The same applies below.

In Model 1, scientific research collaboration had a significant positive impact on the influence of articles (B = 0.135, $p < 0.001$). Compared to single-author research articles, the influence of collaborative research papers was significantly stronger by 13.5%. This showed that the influence of articles is likely to be increased by collaborative research articles compared to research by a single author, supporting H1.

In Model 2, the number of coauthors, collaborative identity, collaborative institution type, collaborative institution span, international collaboration, and discipline collaboration had a significant impact on the influence of the research article. In this model, the number of coauthors had a significant positive effect on the influence of the research article (B = 0.059, $p < 0.001$), which means that if the number of coauthors increased by 1%, the influence of the research article significantly increased by 5.9%.

In Model 3, the effect of the number of coauthors on an article's influence showed diminishing marginal benefits, which is also called the optimal scale phenomenon. Small-scale collaboration may produce optimal benefits [26,27]. Therefore, the quadratic term of the number of coauthors was included for analysis. Moreover, further tests of higher-order terms were no longer significant, indicating that the quadratic term model reached the optimal model fitting. According to the analysis of the quadratic equation, when the number of coauthors was $-\beta_2/(2\beta_3) = 0.081/(2 \times 0.014) = 2.89$, there was an optimal scale phenomenon. In other words, when the number of coauthors was approximately three, the output benefit of the research article influence was the highest, supporting H2. In addition, in terms of collaborative identity, the influence of colleague collaboration articles was 21.7% higher than that of student–student collaborative articles. The influence of teacher–student collaboration articles was significantly higher than that of student–student cooperative papers by 16.1%, indicating that, compared to student–student collaboration, colleague collaboration and teacher–student cooperation have more advantages in terms of article influence. Therefore, H3 was supported. In terms of the type of collaborative institutions, compared to normal–normal university collaboration, the influence of articles produced by normal–comprehensive university collaboration, comprehensive– comprehensive university collaboration, and mixed-institution collaboration was significantly lower—by 22.1%, 16.3%, and 9.1%, respectively—indicating that normal–comprehensive university collaboration was more conducive to improving the impact of research articles; thus, H4 was supported. In terms of the span of collaborative institutions, the influence of collaborative articles across departments was lower than that of collaborative articles within the same department by 1.4%; however, the effect was not statistically significant. Moreover, the influence of collaborative articles produced across universities was 3.7% higher than that of articles produced in the same department, indicating that, compared to the articles produced by cross-departmental collaboration, cross-university collaboration is more conducive to enhancing the influence articles; therefore, H5 was supported.

We found that the influence of international collaboration papers was significantly lower than that of domestic collaboration articles by 9.4%, indicating that international collaboration in Chinese educational empirical research had a significant negative impact on the influence of articles. Thus, H6 was not supported. In terms of disciplinary cooperation, compared to within-disciplinary collaborations, cross-disciplinary collaborations and other disciplinary collaborations significantly increased the impact of articles by 8.1% and 4.3%, respectively, indicating that cross-disciplinary collaboration had a significant positive impact on article influence, supporting H7.

In Model 4, the main focus was to explore the impact of the authorship order in the collaboration between teachers and students on article influence. We found that compared to the articles with an authorship order of teacher ahead and student behind, the influence of articles with an authorship order of student ahead and teacher behind was significantly higher by 41.6%, indicating that the collaborative order of student ahead and teacher behind was more conducive to enhancing the influence of articles. H3 was verified again.

4.4. Heterogeneity Test of the Influence of the Collaboration Production Relationship on Scientific Research Output Quality in the Sustainable Development Progress of Educational Empirical Research

To analyze whether the influence of cooperative production relationship on the scientific research output was affected by the number of collaborators and the identity of the collaboration, that is, the heterogeneity analysis of the factors influencing the scientific research output quality, we used a subsample Poisson regression as shown in Table 5.

Table 5. Heterogeneity test results of cooperative production relationships on research article output quality.

Predictor Variables		Scientific Research Output Quality (Article Influence)			
		Model 1	**Model 2**	**Model 3**	**Model 4**
		Two-Author Collaboration	**Multiple-Author Collaboration**	**Teacher–Student Collaboration**	**Colleague Collaboration**
Intercept		3.116 *** (0.041)	4.078 *** (0.061)	3.517 *** (0.042)	3.441 *** (0.037)
Explanatory Variables	Colleague collaboration	0.239 *** (0.037)	0.013 (0.061)	-	-
	Teacher–student collaboration	0.321 *** (0.036)	−0.169 ** (0.060)	-	-
	Normal U–normal-U	−0.159 *** (0.014)	−0.407 *** (0.023)	−0.281 *** (0.021)	−0.215 *** (0.021)
	Comprehensive U–comprehensive U	−0.259 *** (0.011)	−0.358 *** (0.011)	−0.116 *** (0.022)	−0.292 *** (0.024)
	Mixed institutions	−0.011 (0.014)	−0.327 *** (0.021)	−0.189 *** (0.017)	−0.031 (0.020)
	Cross-department	−0.059 *** (0.011)	0.051 *** (0.011)	−0.111 *** (0.019)	0.047 *** (0.013)
	Cross-university	−0.023 (0.013)	0.102 *** (0.011)	−0.009 (0.013)	0.126 *** (0.014)
	International collaboration	−0.281 *** (0.021)	−0.097 *** (0.020)	0.017 (0.021)	−0.197 *** (0.022)
	Cross-disciplinary interaction	0.081 *** (0.011)	0.121 *** (0.013)	0.017 (0.014)	0.174 *** (0.015)
	Other disciplinary interaction	0.048 *** (0.012)	0.074 *** (0.017)	0.078 *** (0.015)	−0.024 (0.018)
	Number of coauthors	-	-	0.138 *** (0.021)	0.199 *** (0.007)
	Quadratic term of the number of coauthors	-	-	−0.028 *** (0.004)	−0.025 *** (0.002)
Control Variables	Research funding	0.098 *** (0.011)	−0.062 *** (0.013)	0.057 *** (0.011)	0.049 *** (0.014)
	Title of first author	0.027 *** (0.004)	−0.061 *** (0.003)	0.007 * (0.003)	−0.005 (0.005)
	Journal impact factor	0.214 *** (0.003)	0.184 *** (0.005)	0.161 *** (0.004)	0.211 *** (0.005)
Fixed Effect of Institution Type		Yes	Yes	Yes	Yes
Fixed Effect of Publication Time		Yes	Yes	Yes	Yes
Log Likelihood		−26,798.132	−18,547.648	−27,546.654	−15,843.546
N		1940	1186	1911	1176

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

Models 1 and 2 included the samples of two-author collaboration and multiple-author collaboration. In two-author collaboration, colleague and teacher–student collaboration had a higher article influence than that of student–student collaboration; however, this conclusion was not found in the multiple-author collaboration sample. In multiple-author collaborations, the influence of teacher–student collaboration articles was significantly lower by 16.9%, indicating that smaller-scale teacher–student collaboration had a posi-

tive effect on increasing the article influence. In terms of the span of cooperation, the impact of two-author cross-departmental collaboration was significantly lower than that of collaboration conducted in the same department. However, in multiple-author collaborations, the article influence of cross-departmental units and cross-university units was significantly higher than that of articles produced in the same department, indicating that multiple-author cross-unit collaboration is more conducive to improving research article influence.

The samples of teacher–student collaboration and colleague collaboration were included in Models 3 and 4. The number of coauthors in the teacher and student collaboration and colleague cooperation showed a diminishing marginal benefit on the article influence; however, according to the quadratic equation analysis, when the number of collaborators in teacher–student collaboration was $-\beta_2/(2\beta_3) = 0.138/(2 \times 0.028) = 2.46$, the collaborative article influence was the highest. The result also showed that when the number of coauthors in colleague collaboration was $-\beta_2/(2\beta_3) = 0.199/(2 \times 0.025) = 3.98$, the influence of the collaborative article produced the highest output benefit. We found that the best size of teacher–student collaboration was 2–3 people, whereas the best size of colleague collaboration was 3–4 people. In terms of the collaborative institution span, the article influence of the cross-department teacher–student collaboration was significantly lower than that of same-department collaborations; however, for colleague cooperation, the article influence of cross-department collaborations and cross-university collaborations was significantly higher than that of within-department collaborations, indicating that cross-unit collaboration within colleague collaboration is more helpful for enhancing the influence of the research article. In terms of international collaboration, compared to the article influence of domestic teacher–student collaborations, we found no significant difference from that of international teacher–student collaborations, but the influence of international collaboration among colleagues was significantly lower than that of domestic colleague collaborations. This result indicates that the international colleague collaboration cannot considerably improve the article influence in the field of Chinese educational empirical research. From the perspective of disciplinary interaction, other disciplinary interaction collaborations significantly increased article influence compared to within-disciplinary teacher–student collaboration. However, there was no significant effect of teacher–student cross-disciplinary collaboration on article influences due to the sample size of teacher–student cross-disciplinary collaboration. As such, the estimate is likely biased. Moreover, the article influence of colleague cross-disciplinary collaboration was significantly higher compared to that of within-disciplinary collaborative articles, indicating that cross-disciplinary colleague collaboration is more conducive to enhancing the influence of papers.

5. Discussion and Conclusions

Through conducting an informational exploration of 3610 educational empirical research papers published from 2015 to 2020, we examined the influence of collaborative production relationships in the field of Chinese educational empirical research on scientific research output in the sustainable development progress of educational empirical research and obtained several validated findings. On this basis, some considerations for the future improvement of empirical research output in the sustainable development progress of educational empirical research were made.

5.1. Main Conclusion

According to the data analysis, scientific research collaboration can help improve the educational empirical research output quality (article influence), and an optimal scale phenomenon exists for collaborative research. Compared to single-author research articles, the influence of collaborative research articles was significantly higher: by 13.5%. Moreover, the impact of the number of coauthors on the influence of research article showed diminishing, marginal benefits. This means that scientific research collaboration has a significant

positive effect on the influence of educational empirical research articles, and an optimal scale exists for collaborative research: the optimal scale of collaboration is three authors. This conclusion is consistent with research in the field of natural science [26–28].

From the perspective of collaborative identity, we found that collaborative identity has a significant influence on the sustainable improvement of educational empirical research output quality (article influence). Compared to student–student collaborations, teacher–student and colleague collaborations significantly increased the influence of the article by 16.1% and 21.7%, respectively. As for teacher–student collaborations, compared to the teacher ahead and student behind model, student ahead and teacher behind collaboration increased the influence of the research articles by 41.6%. This shows that teacher–student and colleague collaborations are more conducive to enhancing the influence of articles than student–student collaboration. The student ahead and teacher behind collaboration model is more conducive to enhancing the influence of the research articles than the teacher ahead and student behind model. There are similar results in the field of natural science and higher-education research [33,54].

We found that institutional collaboration had a significant impact on the sustainable improvement of educational empirical research output quality (article influence). From the perspective of cooperative institution type, compared to the collaboration among normal universities, the research article influence of other types of institutions was significantly lower. This shows that the strong collaboration among normal universities helps to enhance the influence of research articles. This conclusion is different from Shang's research, which suggests that university–enterprise collaboration has a positive effect on scientific research outcomes in universities [76]; it should be verified further. In terms of the collaborative institution span, compared to collaboration within one department, the influence of collaborative research articles conducted across universities was significantly higher by 3.7%. This shows that, compared to same-department collaboration, the collaboration conducted across universities is more conducive to enhancing research article influence. This statement has been verified in the fields of natural science and higher education [32,42].

International collaboration was found to have a negative impact on the sustainable improvement of educational empirical research output quality (article influence). Compared to domestic collaboration, the influence of international collaborative articles was significantly lower by 9.4%. This means that the international collaboration in Chinese educational empirical research is still in a developing position, and these collaborations have no corresponding benefits in terms of article influence. However, this result is different with most of the research, which claims that international collaboration has a positive effect on scientific research outcomes [51,77]. Therefore, our conclusion needs to be further discussed.

Moreover, student collaboration had a positive impact on the sustainable improvement of educational empirical research output quality (article influence). Compared to within-disciplinary collaborations, cross-disciplinary and other disciplinary collaborations significantly increased article influence by 8.1% and 4.3%, respectively. This demonstrates that cross-disciplinary collaboration has a boosting effect on article influence. This result is supported by research in the fields of natural science and education [55–57].

Finally, we found the effect of collaborative production relationships on the sustainable improvement of educational empirical research output quality (article influence) was affected by the number of coauthors and their identities. In terms of the number of coauthors, teacher–student collaboration on a smaller scale (two-author collaboration) was conducive to increasing the influence of articles. Multiple-author cross-institution collaborations were more conducive to increasing the influence of the paper. In terms of collaborative identity, the optimal scale of teacher–student collaboration was 2–3 authors, and the optimal scale of colleague collaboration was 3–4 authors. Compared to teacher–student collaboration, cross-institution and cross-disciplinary collaborations were more helpful to enhancing the article influence within colleague collaborations. The conclusion of heterogeneity is a finding that has never been mentioned in previous studies, and it is an innovative part of this study that will be further examined in subsequent discussions.

5.2. Discussion

The sustainable development of educational empirical research needs to be promoted by collaborative production relations. This study explores the impact of collaborative production relations in educational empirical research on the quality of research outputs. In order to promote educational empirical research and the sustainable development of educational disciplines, it is necessary to focus on scientific research collaborative production relations, specifically in the following aspects:

The sustainable development of educational empirical research needs a well-guidance teacher–student collaboration. Teacher–student collaborations with an equal relationship, especially with the student ahead and teacher behind authorship model, were demonstrated to have a positive effect on improving the sustainable improvement of educational empirical research outcome quality. This finding was demonstrated in other fields as well [33]. The phenomenon of optimal scale in teacher–student cooperation exists, and the optimal benefit scale was 2–3 authors. This finding is one of the innovative viewpoints of this study. Teacher–student collaboration is the most typical academic inheritance and scientific research cooperation relationship [78], and the motivation for this type of collaboration is its benefits [79]. The two main aims of this kind of collaboration are: cultivating young researchers and allowing them to have their first authorship. Zuckerman [34] conducted a survey of Nobel Prize winners and claimed that the supervisor would arrange the student as the first author in the process of collaboration. This kind of collaboration contributes to the scientific research output and academic career development of the students [80]. However, this does not mean that the scale of teacher–student collaboration can be expanded indefinitely. As a role of the driver in a helpful collaborative relationship, the teacher may be negatively impacted by their students. The more students they guide in collaborative relationships, the more the quality of the research outcome may be degraded [81]. In order to promote the sustainable development of educational empirical research, a well guided collaboration between teachers and students should be encouraged. Additionally, students are supposed to take full initiative in the process of collaboration under the equal collaborative relationship.

Small workshop-style, cross-departmental collaboration should be encouraged in the process of promoting educational empirical research development. Cross-departmental colleague collaboration had a positive effect on the sustainable improvement of output quality and similar results were obtained in other scientific fields [42,82]. The optimal scale phenomenon exists in the process of colleague collaboration, and the optimal scale was 3–4 authors. This finding is one of the innovative viewpoints of this study. Teacher–student collaboration is a helpful relationship, whereas colleague collaboration is a complementary collaborative relationship. The stability of the scientific research environment is conducive to the sustainable collaborative research and improving the output quality [83]. Collaborative relationships among colleagues are longer and more stable than those of teachers and students; however, colleague collaboration inevitably increases competition within the same department, which is not conducive to the sustainable development of collaboration and the sustainable improvement of research output. Therefore, more cross-organizational colleague collaboration has emerged. The more the organizational levels cross over, the more likely innovative ideas will be generated due to differences in systems, institutions, and cultures [84]. At present, the main factors hindering sustainable collaboration across wider borders are the authorship order arrangement and researchers' communication issues [85]. In addition, if the scale of such complementary collaboration becomes too large, some problems will arise, such as difficulties in unifying opinions, overcapacity, and subsequent ineffective collaboration [86]. Accordingly, in order to promote the sustainable development of educational empirical research, it is necessary to promote small workshop-style, cross-organizational colleague collaboration; the authorship order arrangement mechanism of scientific research collaborations should be reformed to stimulate the interest and innovation in colleague collaborations.

According to the data analysis, we found that the collaboration among normal universities should be promoted. Meanwhile, a greater level of communication should be adopted among domestic scholars and foreign scholars, which could promote the sustainable improvement of educational empirical research output quality. Institutional collaboration among normal universities can significantly increase the influence of educational empirical articles, whereas international collaboration significantly reduces the influence of these studies. From the perspective of symbiosis theory, a symbiotic system includes three main elements: the symbiosis unit, symbiosis model, and symbiosis environment [87]. The collaboration among normal universities is the symbiosis unit; they usually have a similar symbiosis model and environment. Additionally, normal universities have unique educational resources. Strong alliances promote the improvement in research article influence. Other studies reported that the articles produced by mixed-institution collaboration usually have a stronger influence, indicating that collaboration among multiple types of institutions can achieve mutual complementarity [32,53]. In this research, it was found that there was a negative correlation between international collaboration and research article quality, and the null hypothesis was rejected. The effect of international collaboration on the influence of educational empirical research articles was not satisfactory. The previous research usually suggest that international collaboration should be helpful to promote the sustainable improvement of research output quality. It is believed that international collaboration promotes resource sharing and ideological innovation, thereby improving the quality of research [88]. However, this study found that this point of view is not applicable in the field of Chinese educational empirical research. The reason for this may be that, in the field of educational empirical research, Chinese educational scholars have not developed in-depth opinion exchanges and resource sharing with international scholars. Through deeply analyzing the information in the sample documents, we found that most of the international collaboration in the field of empirical research on education in China was conducted by domestic scholars by transferring the opinions of foreign scholars. The main contributions may come from the foreign scholars, the Chinese scholars usually play the role of corresponding author, and no substantive research collaboration is produced by international collaborations. In the process of globalization, the collaboration and sharing of Chinese scholars and international scholars has become a force that cannot be ignored in international research [89]. Therefore, to enhance the international vision of Chinese educational scholars, strengthening the sharing of resources and the depth of knowledge communication with international scholars is an important way to promote the sustainable improvement of educational empirical research output quality in the future.

Cross-disciplinary collaboration benefits sustainable improvement of educational empirical research output quality. Cross-disciplinary collaboration has a significant positive impact on research article influence. The findings of this study are the same as those of other disciplines, such as related research in medical nursing [90], water conservancy [91], natural disaster protection [92] and some other disciplines. The findings in these fields show that interdisciplinary collaboration can be helpful to improve the quality of research results, indicating that the finding that interdisciplinary collaboration has the ability to improve research output quality can also be applied to empirical research in education. From the perspective of the proportion of current academic collaboration articles, the field of pedagogy has its own relatively stable discipline structure and characteristics, but this kind of immersive internal collaboration among disciplines cannot effectively enhance article influence. Cross-disciplinary knowledge production is not a simple patchwork and accumulation of knowledge from multiple disciplines, but a knowledge production model based on major social issues and internal logical relationships [93]. In the era of big science, cross-discipline integration has become the mainstream trend. Although the influence of pedagogy in China has significantly strengthened [94], considerable advances are required to address the relationship between the natural and conscious development of cross-disciplinary pedagogy. Accordingly, solving real-world social problems is best achieved through collaborative research, especially with the background that different dis-

ciplines can contribute different types of knowledge to address more complex sustainability challenges [95]. This is also true for education disciplines. Strengthening the interdisciplinary exchange of educational empirical research will undoubtedly become an important way to improve the quality of research output in a sustainable manner.

5.3. Theoretical Contribution and Research Limitations

Researchers and their collaborators play a crucial role in promoting the quality and influence of educational empirical research in China. From a theoretical perspective, this research is helpful for deepening the understanding of the relationship mechanisms of collaborative production relationship and educational empirical article influence. At the same time, from a practical perspective, scientific evidence has been provided to promote the continuous development and quality improvement of future educational empirical research. Although, this research has dug out the bibliometric information of 4610 educational empirical research articles, there is still a lack of analysis of the internal knowledge structure and the article quality of author groups when analyzing the relationship between collaborative production relationships and paper quality. In addition, this research also found that international collaboration had a negative effect on the quality of research articles. Through a deeper exploration of the sample, it was found that part of the reason for this was that international collaboration in Chinese educational empirical research was mainly conducted through citing and translating Western research. More research needs to be conducted in the future to explore the relationship between international collaboration and article quality.

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References

1. Price, D. *Little Science, Big Science*; Columbia University Press: New York, NY, USA, 1963; pp. 20–31.
2. Abramo, G.; D'Angelo, C.A.; Di Costa, F. The effect of multidisciplinary collaborations on research diversification. *Scientometrics* **2018**, *116*, 423–433. [CrossRef]
3. Ma, R.; Li, Z. High Citation or Zero Citation: Exploring the Optimal Scale of Research Cooperation Based on the Citation of Scientific Publication—Evidence from the Financial Times TOP 45 Journals. *J. China Soc. Sci. Technol. Inf.* **2020**, *39*, 1182–1190. [CrossRef]
4. Abramo, G.; D'Angelo, C.A.; Murgia, G. The collaboration behaviors of scientists in Italy: A field level analysis. *J. Informetr.* **2013**, *7*, 442–454. [CrossRef]
5. Schorr, B.; Braig, M.; Fritz, B.; Schütt, B. The global knowledge value chain on sustainability: Addressing fragmentations through international academic partnerships. *Sustainability* **2021**, *13*, 9930. [CrossRef]
6. Tejada, G.; Cracco, M.; Bouleau, C.R.; Bolay, J.C.; Hostettler, S. Testing analytical frameworks in transdisciplinary research for sustainable development. *Sustainability* **2019**, *11*, 4343. [CrossRef]
7. Burke, P. *What Is the History of Knowledge?* Polity Press: Cambridge, CA, USA, 2016; p. 203.
8. East China Normal University. East China Normal University Action Statement on Empirical Research in Education. *J. East China Norm. Univ. Educ. Sci.* **2017**, *35*, 1–3. [CrossRef]

9. Journal of East China Normal University (Education Science). Strengthen educational empirical research and improve the level of educational research—The Second National Special Forum on Educational Empirical Research and National Joint Conference on Educational Empirical Research. Summary of the fruits. *J. East China Norm. Univ. Educ. Sci.* **2017**, *35*, 18–36. [CrossRef]
10. Zhu, J.; Ma, Y. Empirical Education Research in China (2015–2019): Characteristics, Trends and Prospects. *J. East China Norm. Univ. Educ. Sci.* **2020**, *38*, 16–35. [CrossRef]
11. Wang, Y.; Yang, X.; Yu, H.; Cao, J. The Collaboration Pattern and Comparative Analysis of Research Teams in the Artificial Intelligence Field. *Libr. Inf. Serv.* **2020**, *64*, 14–22. [CrossRef]
12. Timothy, W.; Sandra, G.; Julia, M.G.; Moore, Z.; Abigail, S. Cooperation across organizational boundaries: Experimental evidence from a major sustainability science project. *Sustainability* **2014**, *6*, 1171–1190. [CrossRef]
13. Fu, W.J.; Liang, X.; Wei, F.Q.; Cao, J.S.; Chen, W.C.; Mao, Y.Y.; Yu, T.N. Understanding the Scientific Cooperation in Incidental Gallbladder Cancer: From a Bibliometric Perspective. *J. Gastrointest. Surg.* **2020**, *3*, 821–824. [CrossRef] [PubMed]
14. Li, L.; Tang, C. How does inter-organizational cooperation impact organizations' scientific knowledge generation? Evidence from the biomass energy field. *Sustainability* **2020**, *13*, 191. [CrossRef]
15. Letina, S.; Zauder, K.; Jokic, M. The productivity of Croatian psychologists: A scientometric analysis of network cooperation on works indexed in the WoS database from 1991 to 2010. *Suvrem. Psihol. Contemp. Psychol.* **2012**, *15*, 97–117. [CrossRef]
16. Ardanuy, J. Scientific collaboration in Library and Information Science viewed through the Web of Knowledge: The Spanish case. *Scientometrics* **2012**, *90*, 877–890. [CrossRef]
17. Freeth, R.; Caniglia, G. Learning to collaborate while collaborating: Advancing interdisciplinary sustainability research. *Sustain. Sci.* **2019**, *15*, 247–261. [CrossRef]
18. Adams, J. The fourth age of research. *Nature* **2013**, *497*, 557–560. [CrossRef] [PubMed]
19. Beaver, D.; Rosen, R. Studies in scientific collaboration: Part I. The professional origins of scientific co-authorship. *Scientometrics* **1978**, *1*, 65–84. [CrossRef]
20. Zhu, S.; Shen, H.; Huo, L.; Mao, J.; Kang, J. Scientific Research Cooperation Effect on the Quality of Output Papers—Taking East China University of Science and Technology as An Example. *J. Mod. Inf.* **2018**, *38*, 164–170. [CrossRef]
21. Lv, J. The Quantitative Methods in Education Empirical Research in China: A Review on Five Years' Application. *J. East China Norm. Univ. Soc. Sci.* **2020**, *39*, 36–55. [CrossRef]
22. Nivash, J.P.; Babu, L. Analyzing the Impact of News Trends on Research Publications and Scientific Collaboration Networks. *Concurr. Comput.* **2019**, *31*, e5058. [CrossRef]
23. Zhe, C.; Lu, X.F.; Xiong, X. Analysis of Influence Factors on the Quality of International Collaboration Research in the Field of Social Sciences and Humanities: The Case of Chinese World Class Universities (2015–2019). *Sage Open* **2021**, *11*, 1–12. [CrossRef]
24. Lawani, S. Some bibliometric correlates of quality in scientific research. *Scientometrics* **1986**, *9*, 13–25. [CrossRef]
25. Chen, X.; Sun, Y. Collaboration Group Size and It's Impact on the Quality of S.C.C. Ting' s Scientific Performance—Based on the Analysis of the Relationship between the Number of Co-authors and the Citation Count of His SCI Papers. *J. Dialectics Nat.* **2010**, *32*, 56–63. [CrossRef]
26. Franceschet, M.; Costantini, A. The effect of scholar collaboration on impact and quality of academic papers. *J. Informetr.* **2010**, *4*, 540–553. [CrossRef]
27. Liu, Z. Discover the Phenomenon of Optimal Collaboration Size in Science. *Stud. Sci. Sci.* **2012**, *30*, 481–486. [CrossRef]
28. Yang, R.; Li, X. The Correlation Study of Scientific Collaboration and the Influence of Paper. *J. Mod. Inf.* **2019**, *39*, 125–133. [CrossRef]
29. Dennis, D. Reflections on developing collaborative research in pediatric psychology: Implications and future directions. *J. Pediatric Psychol.* **2013**, *07*, 700–707. [CrossRef]
30. Baptista, B.V.; Vilsmaier, U. Models of transdisciplinary knowledge production at universities: A Romanian case study. *High. Educ. Res. Dev.* **2021**, *3*, 1–16. [CrossRef]
31. Leahey, E. From Sole Investigator to Team Scientist: Trends in the Practice and Study of Research Collaboration. *Annu. Rev. Sociol.* **2016**, *42*, 81–100. [CrossRef]
32. Liu, J.; Shao, L. Chinese Core Journals of Higher Education Co-authored Papers Phenomenon—Based on 2015 18 higher Chinese core journals literature statistics. *China High. Educ. Res.* **2016**, *4*, 39–44. [CrossRef]
33. Liang, L.; Liu, J. Pattern of Authors' Name-ordering in S&T Paper Co-Authored by Graduate Students and Their Tutors. *J. Dialectics Nat.* **2003**, *5*, 47–53. [CrossRef]
34. Zuckerman, H. *Scientific Elite: Nobel Laureates in the United States*; Transaction Publishers: New Brunswick, UK; London, UK, 1976; p. 99.
35. AlShebli, B.; Makovi, K.; Rahwan, T. The association between early career Informal mentorship in academic collaborations and Junior author performance. *Nat. Commun.* **2020**, *11*, 5855. [CrossRef] [PubMed]
36. Xie, R.; Li, X.; Han, X.; Shi, S. Evaluation Index of Author Influence Based on Weighted Cited Frequency and Signature Order. *Inf. Sci.* **2018**, *36*, 90–93. [CrossRef]
37. Mccann, T.V.; Meg, P. Addressing the vexed issue of authorship and author order: A discussion paper. *J. Adv. Nurs.* **2018**, *74*, 2064–2074. [CrossRef] [PubMed]
38. Yu, X.; Paudel, K.P.; Li, D.; Xiong, X.; Gong, Y. Sustainable collaborative innovation between research institutions and seed enterprises in China. *Sustainability* **2020**, *12*, 624. [CrossRef]
39. Shi, W.; Yang, W.; Du, D. The scientific cooperation network of Chinese scientists and its proximity mechanism. *Sustainability* **2020**, *12*, 660. [CrossRef]

40. Li, K. The Universities Scientific Research's Cooperative Innovation in Urban Agglomeration in the Middle Reaches of the Yangtze River: Pattern, Feature and Strategy—The Social Network Analysis Based on 14 Research Universities. *J. Xiangtan Univ. Philos. Soc. Sci.* **2017**, *41*, 23–27. [CrossRef]
41. Guo, Y.; Yang, S.; Kuang, P. A Comparative Study on the Cooperation Model of Library and Information Science in China and Foreign Countries. *Inf. Stud. Theory Appl.* **2013**, *36*, 120–123. [CrossRef]
42. Abramo, G.; D'Angelo, C.A.; Di Costa, F.; Solazzi, M. University–industry collaboration in Italy: A bibliometric examination. *Technovation* **2009**, *29*, 498–507. [CrossRef]
43. Ling, Y.; Hu, B.W.; Wang, L.W. Rethinking and Reflecting on Cooperation between Schools and Enterprises: Research into the concept of School Enterprise Cooperation. *Think. Ski. Creat.* **2021**, *42*, 100865. [CrossRef]
44. Yang, S.; Cao, H. A Comparative Study of Co-authoring Models of Archives Discipline in China and Foreign Countries. *Arch. Sci. Bull.* **2014**, *4*, 9–14. [CrossRef]
45. Vishnumaya, R.S.; Nishy, P.; Mini, S. Scientometrics of rare earths research in India. *Curr. Sci.* **2016**, *110*, 1184–1192. [CrossRef]
46. Yu, X. Analysis of the status quo and trend of international collaborative papers by research universities. *Fudan Educ. Forum* **2014**, *12*, 49–55. [CrossRef]
47. Proximity Relations: Elements for an Analytical Framework. Available online: https://www.researchgate.net/publication/265745799 (accessed on 11 December 2021).
48. Lublinski, A.E. Does geographic proximity matter? Evidence from clustered and non-clustered aeronautic firms in Germany. *Reg. Stud.* **2003**, *37*, 453–467. [CrossRef]
49. Hirv, T. Effects of European union funding and international collaboration on estonian scientific impact. *J. Scientometr. Res.* **2019**, *7*, 181–188. [CrossRef]
50. Liu, Y.; Ma, J.; Song, H.; Qian, Z.; Lin, X. Chinese universities' cross-border research collaboration in the social sciences and its impact. *Sustainability* **2021**, *13*, 10378. [CrossRef]
51. Barjak, F.; Robinson, S. International collaboration, mobility and team diversity in the life sciences: Impact on research performance. *Soc. Geogr.* **2008**, *3*, 23–36. [CrossRef]
52. Adams, J.D.; Black, G.C.; Clemmons, J.R.; Stephan, P.E. Scientific teams and institutional collaborations: Evidence from US universities, 1981–1999. *Res. Policy* **2005**, *34*, 259–285. [CrossRef]
53. He, H.; Li, F. The impact of university scientific research cooperation on the quality of paper output–Based on the analysis of the State Key Laboratory. *J. Beijing Inst. Technol. Soc. Sci. Ed.* **2017**, *19*, 162–167. [CrossRef]
54. Cui, H.; Wang, D. Research on individual, institution and regional scientific research cooperation in the field of higher education research in China–Based on the analysis of co-authored documents of 18 educational Chinese core journals in 2016. *China High. Educ. Res.* **2017**, *4*, 48–55. [CrossRef]
55. Ma, Y.Q.; Yao, H. Research on the impact of academic resume on empirical research output of educational scholars—Based on the analysis of core authors from 2015 to 2019. *Chin. High. Educ. Res.* **2020**, *9*, 73–79. [CrossRef]
56. Hu, G.W.; Wang, G.H. Disciplinary and ethnolinguistic influences on citation in research articles. *J. Engl. Acad. Purp.* **2014**, *14*, 14–28. [CrossRef]
57. Steele, T.W. The impact of interdisciplinary research in the environmental sciences: A forestry case study. *J. Am. Soc. Inf. Sci.* **2000**, *51*, 476–484. [CrossRef]
58. Lariviere, V.; Gingras, Y. On the relationship between interdisciplinarity and scientific impact. *J. Am. Soc. Inf. Sci. Technol.* **2010**, *61*, 126–131. [CrossRef]
59. Li, D.; Tong, S.; Li, J. Research on the relationship between interdisciplinary and scientists' academic influence. *Data Anal. Knowl. Discov.* **2018**, *2*, 1–11. [CrossRef]
60. Tsang, W.; Luo, Y.; Ye, J. In Search of the Meaning of Positive Research: A Retrospect of the Positivist Dispute in Social Science Research. *Peking Univ. Educ. Rev.* **2018**, *3*, 104–129. [CrossRef]
61. Cheng, J.; Chen, J. Empirical Educational Research: Its Past, Present and Future. *J. East China Norm. Univ. Educ. Sci.* **2017**, *3*, 150–158. [CrossRef]
62. Wallen, N.E.; Fraenkel, J.R. *Educational Research: A Guide to the Process*; Lawrence Erlbaum Associates: New Jersey, NJ, USA, 2001; p. 9.
63. Lund, T. A metamodel of central inferences in empirical research. *Scand. J. Educ. Res.* **2005**, *49*, 385–398. [CrossRef]
64. Ribeiro, H.C.M. Analyzing the collaboration and scientific production of the teaching and research area in Administration and Accounting. *Perspect. Cienc. Inf.* **2020**, *25*, 194–222. [CrossRef]
65. Li, Z.; Gao, H.; Zhang, Z. The Modern Transformation of Knowledge Production Mode and the Mode Innovation of University Research. *Educ. Res.* **2014**, *35*, 55–63.
66. Benckendorff, P.; Zehrer, A. Career and collaboration patterns in tourism research. *Curr. Issues Tour.* **2014**, *19*, 1386–1404. [CrossRef]
67. Alonso, S.; Cabrerizo, F.J.; Herrera-Viedma, E.; Herrera, F. Hg-index: A new index to characterize the scientific output of researchers based on the h-and g-indices. *Scientometrics* **2010**, *82*, 391–400. [CrossRef]
68. Prathap, G. The 100 most prolific economists using the p-index. *Scientometrics* **2010**, *84*, 167–172. [CrossRef]
69. Li, Y.; Liu, J. Did empirical research on education improve the quality and influence of academic papers—Taking the field of education academic research in mainland China as an example. *Res. Educ. Dev.* **2021**, *41*, 63–77. [CrossRef]
70. Naude, F. Comparing downloads, mendeley readership and Google Scholar citations as indicators of article performance. *Electron. J. Inf. Syst. Dev. Ctries.* **2017**, *78*, 1–25. [CrossRef]

71. Zhang, L.; Sun, B.; Wang, X.; Huang, Y. The impact of interdisciplinarity: Distinct effects on usage and citation. *J. China Soc. Sci. Technol. Inf.* **2020**, *39*, 469–477. [CrossRef]
72. Xie, J.; Gong, K.; Cheng, Y.; Qi, E. Meta-analysis of the correlation between downloads and citations at paper level. *J. China Soc. Sci. Technol. Inf.* **2017**, *36*, 1255–1269.
73. Jonkers, K.; Cruz-Castro, L. Research upon Return: The Effect of International Mobility on Scientific Ties, Production and Impact. *Res. Policy* **2013**, *42*, 1366–1377. [CrossRef]
74. Li, W.; He, J.; Dong, J. The impact of international cooperation and overseas experience on the quality of scientific researchers' papers: Taking life sciences as an example. *Manag. Rev.* **2018**, *30*, 68–75. [CrossRef]
75. Pan, K.; Yuan, J. Research on the scientific research and innovation ability of Chinese urban higher education—Based on the analysis of the scientific research papers of 17 higher education Chinese core journals in 2014. *Chin. High. Educ. Res.* **2015**, *7*, 33–40. [CrossRef]
76. Shang, J.; Zhang, K.; Liu, S. The relationship between knowledge potential matching and innovation performance of university-enterprise cooperation: The moderating effect of geographic proximity. *Technol. Anal. Strateg. Manag.* **2021**, 1118. [CrossRef]
77. Wagner, C.S.; Whetsell, T.A.; Mukherjee, S. International research collaboration: Novelty, conventionality, and atypicality in knowledge recombination. *Res. Policy* **2019**, *48*, 1260–1270. [CrossRef]
78. Editorial. Science needs mentors. *Nature* **2019**, *573*, 5. [CrossRef]
79. Floyd, S.W.; Schroeder, D.M.; Finn, D.M. "Only if I'm first author": Conflict over credit in management scholarship. *Acad. Manag. J.* **1994**, *37*, 734–747. [CrossRef]
80. Ma, Y.; Mukherjee, S.; Uzzi, B. Mentorship and protege success in STEM fields. *Proc. Natl. Acad. Sci. USA* **2020**, *117*, 14077–14083. [CrossRef]
81. Pranji, S. Development of a caring teacher-student relationship in higher education. *J. Educ. Cult. Soc.* **2021**, *12*, 151–163. [CrossRef]
82. Cheol, S.J.; Jeung, L.S.; Kim, Y. Research collaboration across higher education systems: Maturity, language use, and regional differences. *Stud. High. Educ.* **2013**, *38*, 425–440. [CrossRef]
83. Zhao, J.; Liao, J. Summary of research cooperation in scientific research. *Sci. Manag. Res.* **2013**, *31*, 117–120. [CrossRef]
84. Davenport, T.H.; Klahr, P. Managing customer support knowledge. *Calif. Manag. Rev.* **1998**, *40*, 195–208. [CrossRef]
85. Liang, W.; Liu, J.; Wang, W. Faculty Research Collaboration and Research Productivity in Research Universities—Taking the Faculty of Education of Beijing Normal University as an Example. *Teach. Educ. Res.* **2015**, *27*, 31–39. [CrossRef]
86. Noonan, P.; Erickson, A.G.; McCall, Z.; Frey, B.B.; Zheng, C.M. Evaluating change in interagency collaboration of a state-level interagency education team: A social network approach within a utilization-focused framework. *Educ. Assess. Eval. Account.* **2014**, *26*, 301–316. [CrossRef]
87. Yuan, C. *Symbiosis Theory: On the Small Economy*; Beijing Economic Science Press: Beijing, China, 1998; pp. 1–30.
88. Abramo, G.; Angelo, C.A.D.; Solazzi, M. Are Researchers that Collaborate More at the International Level Top Performers? An Investigation on the Italian University System. *J. Informetr.* **2011**, *5*, 204–213. [CrossRef]
89. Ravinet, P.; Chou, M.H. Higher education regionalism in Europe and Southeast Asia: Comparing policy ideas. *Policy Soc.* **2017**, *36*, 143–159. [CrossRef]
90. Mckenna, H.P. Nursing and interdisciplinary research: Phoenix or dodo? *J. Multidiscip. Healthc.* **2020**, *13*, 1075–1078. [CrossRef]
91. Rangecroft, S.; Rohse, M.; Banks, E.W.; Day, R.; Di Baldassarre, G.; Frommen, T.; Hayashi, Y.; Höllermann, B.; Lebek, K.; Mondino, E.; et al. Guiding principles for hydrologists conducting interdisciplinary research and fieldwork with participants. *Hydrol. Sci. J.* **2021**, *66*, 214–225. [CrossRef]
92. Sherman-Morris, K.; Houston, J.B.; Subedi, J. Theoretical matters: On the need for hazard and disaster theory developed through interdisciplinary research and collaboration. *Risk Anal.* **2018**, *41*, 1059–1065. [CrossRef] [PubMed]
93. Li, L.G.; Zhao, K. Types and Experiences of Interdisciplinary Knowledge Production: Taking the Nobel Prize for Natural Science in the 21st Century as an Example. *Univ. Educ. Sci.* **2021**, *5*, 14–23. [CrossRef]
94. Hou, H.; Yuan, Z. Retrospect and Prospect of the Development of Pedagogy Interdisciplinary in China. *Univ. Educ. Sci.* **2021**, *5*, 4–13. [CrossRef]
95. Knickel, M.; Knickel, K.; Galli, F.; Maye, D.; Wiskerke, J.S.C. Towards a Reflexive Framework for Fostering Co—Learning and Improvement of Transdisciplinary Collaboration. *Sustainability* **2019**, *11*, 6602. [CrossRef]