Volume 16
Number 01
May, 2023

SIEF

science insights education frontiers

pISSN: 2644-058X eISSN: 2578-9813

Published Bimonthly by
Insights Publisher

Science Insights Education Frontiers

pISSN 2644-058X
eISSN 2578-9813
(Monthly Since January 2023)

Volume 16, No. 1

May 2023

Insights Publisher

Science Insights Education Frontiers

pISSN 2644-058X
eISSN 2578-9813

http://www.bonoi.org/index.php/sief

Is Indexed/Abstracted by


Science.gov


refseek*
Academic Search Engine


Semantic Scholar


EuroPub


Scilit


KUDOS


zenodo

Science Insights Education Frontiers

ARIANE BAYE
Department of Education and Training
University of Liege
Belgium

GEOFFREY D. BORMAN
Mary Lou Fulton Teachers College
Arizona State University,
USA

XIAOQIAO CHENG
School of Education Science
Nanjing Normal University
China

BEVERLY IRBY
Educational Administration and Human Resource Development
Texas A&M University
USA

ÖZGÜL KELEŞ
Faculty of Education
Aksaray University
Turkey

ICY LEE
Department of Curriculum and Instruction
The Chinese University of Hong Kong
Hong Kong, China

TILAHUN ADAMU MENGISTIE
College of Education
University of Gondar
Ethiopia

CLEMENT KA-KIT NG
Centre for University and School Partnership
The Chinese University of Hong Kong
Hong Kong, China

MARTA PELLEGRINI
Department of Education, Languages, Intercultures, Literatures, and Psychology
University of Florence
Italy

MARIA JOSÉ SAMPAIO DE SÁ
CIPES – Centre for Research in Higher Education Policies
Universidade de Aveiro
Portugal

SANDRO N.F. DE SERPA
Department of Sociology
Faculty of Social and Human Sciences
University of The Azores
CICS.UAc/CICS.NOVA.UAc & NICA-UAc
Portugal

FUHUI TONG
College of Education and Human Development
Educational Psychology
Texas A&M University
USA

GIULIANO VIVANET
Dipartmento di Pedagogia, Psicologia, Filosofia
University di Cagliari
Italy

ANNE WADE
Centre for the Study of Learning and Performance (CSLP)
Concordia University

Canada

JIJUN YAO
School of Education Science
Nanjing Normal University
China

Executive Publisher
Insights Publisher

TABLE OF CONTENTS

SIEF, Vol. 16, No. 1, May 2023

COMMENTARY

Internet Addiction: A Concerning Issue among Chinese College Students

Yaodong Yang

Jiangsu Normal University, Xuzhou 221116, Jiangsu, China

"Once the internet colonizes you in a bad way, so your future too." –Rey L. Lapatha

THE advent of computers initiated the information revolution, fundamentally transforming individuals' ways of life. The use of internet brings about unprecedented convenience, efficiency, and abundance of information. For college students, the internet has significantly enriched their lives, opened more learning channels, and increased learning resources, as a result, broadening their horizons, facilitating academic exchanges, and making learning more engaging. On the other hand, the problematic use of internet such as internet dependence among some of them has imposed detrimental effects on their academic achievement as well as their mental and physical health.

Internet addiction disorder also referred to as pathological Internet use (PIU), is a new type of mental disorder that has emerged with the application and popularization of the Internet. The issue of internet addiction was first raised by American psychiatrist Ivan Goldberg in 1994, who defined it as a condition in which the user spends unreasonably lengthy periods of time online and fails to control this compulsive act. Internet addiction disorder is comparable to pathological gambling (Young, 1997; Hollander et al., 2000), with symptoms including increased tolerance, withdrawal, emotional disorders (such as depression, anxiety), social relationship disruption (reduced quantity or degraded quality of social connections) and more.

The internet addiction rate among Chinese college students has been trending upward over the past few years. According to the *46th Statistical Report on China's Internet Development* published by the China Internet Network Information Center, by September 2020, China had an Internet penetration rate of 67.0% and 940 million internet users, with students accounting for 28.2% (CNNIC, 2020). Internet dependence has become a major risk factor for the declining health and impeded academic development in higher education students. The *48th Statistical Report on China's Internet Development* revealed that the internet addiction rate among college students was 10.7% (Li, 2021). Research has

demonstrated that internet addiction has a deleterious impact on academic levels, mental state, and everyday lives of college students. Specific consequences include but not limited to physical degeneration, memory loss, thinking ability degradation, and poor social adaptation. Therefore, in-depth analysis of factors contributing to college student Internet dependence is critical to the prevention and intervention of pathological Internet use in them.

The article titled "*Internet Addition among College Students in China and Its Underlying Causes*" (Xia, 2023) in this issue provides an overview of internet addiction among Chinese college students, pinpoints its causes, and highlights its adverse effects, based on the analysis of previous relevant studies. It is hoped this study can spark more discussions on this subject.

References

CNNIC. (2020). The 46th Statistical Report on China's Internet Development. China Internet Network Information Center. (2020-09-29). Available at: https://www.cnnic.cn/NMediaFile/old_attach/P020210205509651950014.pdf

Hollander, E., Buchalter, A. J., & DeCaria, C. M. (2000). Pathological gambling. *Psychiatric Clinics of North America*, 23(3):629-642. DOI: https://doi.org/10.1016/s0193-953x(05)70185-4

Li, Z. W. (2021, August 28). The number of internet users in China exceeds one billion. Guangming Daily. p.003.

Xia, X. (2023). Internet addiction among college students in China and its underlying causes. *Science Insights Education Frontiers*, 16(1):2457-2473. DOI: https://doi.org/10.15354/sief.23.re127

Young, K. S. (1997). What makes the Internet addictive: Potential explanations for pathological Internet use. In 105th annual conference of the American Psychological Association (Vol. 15, pp. 12-30). Chicago.

***Correspondence to**:*
Yaodong Yang
School of Education Science
Jiangsu Normal University
Xuzhou 221116
Jiangsu
China
E-mail: 986822877@qq.com

***Conflict of Interests**: None.*

***Doi:** 10.15354/sief.23.co072*

ORIGINAL ARTICLE

Trends and Issues in Science Education in the New Millennium: A Bibliometric Analysis of the JRST

Ozgur Kivilcan Dogan

Marmara University, Istanbul, Turkey

***Abstract**: As a real time socio-scientific issue, the COVID-19 pandemic has clearly shown us the need for the public to understand science. As experts have repeatedly stressed in recent years, science education plays an important role in developing scientifically literate societies. In this context, it is critical to consider which subjects science educators frequently concentrate on and the messages they give to researchers, policymakers, and other stakeholders. Therefore, the purpose of this study was to use bibliometric data to understand the topics that the articles in the Journal of Research in Science Teaching (JRST), one of the flagship journals about science education and teaching, focused on over the last 20 years. This study employed both descriptive and bibliometric analysis. Based on data from the Web of Science (WoS), descriptive analyses are presented as frequencies and percentages and we used VOSviewer software for bibliometric analysis. Findings showed that more than 80% of the authors of the JRST are from the United States, Australia, Canada, and the United Kingdom. Moreover, results of these analyses demonstrate that the researchers publishing in the JRST focused on two main ideas over the past 20 years: "Which science teaching methods and strategies are most effective?" and "What can be done to make science teaching more inclusive?" As a result, it can be clearly seen that JRST has special attention on inclusive approach in science education which should be designed to include traditionally underrepresented groups.*

Science Insights Education Frontiers 2023; 16(1):2375-2407.
Doi: 10.15354/sief.23.or249

How to Cite: Dogan, O.K. (2023). Trends and issues in science education in the new millennium: A bibliometric analysis of the JRST. Science Insights Education Frontiers, 16(1):2375-2407.

Keywords: *Bibliometric Analysis, JRST, Inclusive Education, Science Education*

About the Author*: Ozgur Kivilcan Dogan, Prof., PhD, Department of Biology Education, Faculty of Education, Marmara University, Goztepe, 34722, Istanbul, Turkey. E-mail: odogan@marmara.edu.tr, ORCID: https://orcid.org/0000-0002-3213-2345*

Correspondence to*: Ozgur Kivilcan Dogan at Marmara University of Turkey.*

Conflict of Interests*: None*

Acknowledgments: *I would like to thank Dr. Sedat Gümüş and Dr. Serhat İrez for their generous help in this project.*

Introduction

CULTIVATING a scientifically literate society is critical to making sense of and producing solutions to many of the most pressing issues facing the world today. As a real time socio-scientific issue, the COVID-19 pandemic has clearly demonstrated the need for the public to understand science (Reiss, 2020). It is not only pandemics that necessitate this type of widespread scientific literacy, but also wars, unequal distributions of global resources, environmental problems, and socio-cultural disparities, and civil rights. Individual nations and international organizations develop policies to address these issues based on scientific studies conducted by experts. As experts have repeatedly stressed in recent years, science education plays an important role in developing scientifically literate societies (Bybee, 1997; Roberts & Bybee, 2014; Roth & Barton, 2004). In this context, it is critical to consider which subjects science educators frequently concentrate on and the messages they give to researchers, policymakers, and other stakeholders. Therefore, synthesizing previous studies will help us advance this line of research (Zupic & Cater, 2015). Similarly, if we understand the history of science education, we can understand our current shortcomings and make more reliable predictions about the future (Yager, 2000). As a result, the present study aimed to use bibliometric data to understand the topics of the articles published in the *Journal of Research in Science Teaching* (JRST), one of the flagship journals about science education, over the last 20 years. Thus, we generated the following research questions:

1. *What are the descriptive characteristics of the studies published in JRST over the past 20 years?*
2. *What does the intellectual structure of the past 20 years of JRST publications look like?*

Why JRST?

The current body of knowledge in a particular field is the result of years of scientific communication between communities of researchers (Assefa & Rorissa, 2013). In this context, the output of scientific communication consists of journal articles, books, and conference papers. Using bibliometric techniques to analyze the knowledge structure and scientific characteristics of a particular journal's publications can provide a guide for the journal's authors, as well forecast the journal's future development. In addition, it can reveal the current status and development trends of a journal, providing the opportunity to evaluate its contribution to the field (Xu et al., 2018). Such studies can take place on a small scale, for example for an internal evaluation of a journal, or at a high level, such as shaping the science policy of an entire country (Al et al., 2010). For this study, we focused our attention on review-

ing the Journal of Research in Science Teaching (JRST). The JRST is the official journal of the National Association for Research in Science (NARST), a global consortium dedicated to improving science education through research. As one of the most important science education journals included in the Social Sciences Citation Index, this journal was a natural choice for this research, since it has a strong influence on the field globally and provides important insight into current trends in science education publications. According to Journal Citation Reports data, the JRST ranked 49th among 263 "education & educational research" journals in 2022, with an impact factor of 3.918.

Theoretical Background: What does Bibliometric Analysis do?

The goal of research synthesis is to place individual studies in conversation with each other, to put their findings into perspective (Leary & Walker, 2018). Due to the rapid increase of research in science education in recent years, it is important to examine this large amount of existing educational research data from a bird's eye view to develop future studies and policies (Authors, 2021). With such a wealth of research, it is becoming increasingly difficult for scholars to keep up with the relevant literature in their field. Therefore, researchers should employ various methods to cope with the richness of this data, filter important studies by predicting their real effects, and produce meaningful results by discovering the structure underlying the field. Several different field review approaches can be used depending on the review's goals, as well as the amount and nature of the literature to under analysis (Donthu et al., 2021); the most popular of these methodologies include meta-analysis, meta-synthesis, and bibliometry. Meta-synthesis is a method from the qualitative paradigm (Leary & Walker, 2018). Meta-analysis, which works quantitatively, reveals relationships that are not examined in researched studies by using empirical evidence (Donthu et al., 2021). On the other hand, bibliometric studies summarize large volumes of bibliometric data (such as keywords and citations) to present the intellectual structure and emerging trends of a research topic or field (Donthu et al., 2021; Güneş et al., 2017; Pritchard, 1969; Zupic & Cater, 2015).

Bibliometry involves statistical analysis of written publications, such as books, articles or conference papers (Pritchard, 1969). This area of research began when Hulme coined the term "statistical bibliography" in 1922 (Pritchard, 1969). Later, Pritchard (1969) drew attention to the importance of the concept and proposed a new term, stating that "...it is to be hoped…this term BIBLIOMETRICS will be used explicitly in all studies which seek to quantify the processes of written communication and will quickly gain ac-

ceptance" (p. 2). Bibliometry then attracted the attention of researchers from diverse scientific fields, who applied it to their own areas of study (Merigo & Yang, 2017). Used for decades to evaluate the research performance of individuals, teams, and academic units in various scientific fields, this method offers the potential to recognize interdisciplinary collaboration, investigate the structure of scientific fields, and document the impact of science and technology (e.g., publications and patents) research on scientific progress (Anninos, 2014; Moed, 2005; Narin, 1976).

Traditionally, bibliometric approaches are used to determine the scientific and academic value of a particular journal, identify the key scholars and documents in a research field (through co-authorship, citation, or co-citation), and create thematic maps to identify popular and emerging topics, collaboration patterns, and interdisciplinary models through co-word or co-occurrence analysis (Anninos, 2014; Assefa & Rorissa, 2013; Callon et al., 1986; Hallinger & Kovačević, 2019; Laengle et al., 2018). Bibliometry can also quantify the timeliness of a discipline's content (Al et al., 2010). Moreover, bibliometric methods provide a useful tool in literature reviews before reading even begins, by guiding the researcher to the most influential studies and mapping the research area without subjective bias (Zupic & Cater, 2015).

Analyzing the publications of a specific journal can yield several benefits. Peer-reviewed academic journals are seen as the most reliable sources of knowledge in the scientific community (Gholampour et al., 2019). These journals present new developments in a field to the scientific community through an objective review process, and the citations that these studies receive spread this information and increase its reliability (Westbrook, 1960). As a result, analyzing the content and citations of studies published in peer-reviewed journals provides us with information about what is credible and widely accepted in each field. Furthermore, by reviewing particularly prominent journals, researchers can make data-based assertions to editors, authors, and readers on to advance and diversify the field through prioritizing particular articles and themes.

Donthu et al. (2021) grouped the main techniques of bibliometric analysis into two categories: *performance analysis and science mapping*. Publication- and citation-related metrics are used in performance analysis, which offers clues about trends in the field. On the other hand, citation, co-citation, co-authorship, and co-occurrence (co-word) analysis are typical of science mapping (Donthu et al., 2021; Zupic & Cater, 2015). When describing the benefits and drawbacks of science mapping techniques, Zupic and Cater (2015) firstly explained that while citation analysis quickly reveals key studies in a field, it may be biased against newer studies that have not yet received many citations. Secondly, they contend that co-citation analysis is the most widely used and valid science mapping method. Mapping the studies that appear in the same reference lists reveals which schools of thought

have the broadest impact on the field. However, for a pattern to emerge, studies must be cited together many times; thus, as in citation analysis, co-citation maps will not depict studies with a low number of citations. Lastly, while co-authorship analysis reveals the social structure of a field, co-occurrence analysis plays an important role in defining the field by mapping the actual content of studies. Different representations and interpretations of a single concept or theme may pose a problem for this type of analysis, however.

The literature provides many examples of bibliometric analyses similar to the present study. For example, Abramo et al. (2012) used bibliometric analysis to explore the contributions of Italian universities; Diem and Wolter (2013) investigated Swiss scientists in educational research; and Budd and Magnusson (2010) and Earp (2010) mapped higher education studies and journals. Additionally, while Laengle et al. (2017) traced trends from the *European Journal of Operational Research*, Merigo and Yang (2017) applied similar methods to analyze the *International Journal of Intelligent Systems*. Finally, Gümüş et al. (2020) analyzed the contributions of Turkish researchers to the field of Educational Leadership and Management, and Phelan (2000) conducted similar research on Australian scholars in international education. The present study focused on articles published between 2000 and 2020 in one of the prominent journals in the field of science education, JRST. Consequently, it is believed that the bibliometric structure of this journal (or any other prominent journal) will provide solid evidence of the current state of science education.

Methods

This study employed both descriptive and bibliometric analysis. Based on data from the Web of Science (WoS), and present the descriptive analyses as frequencies and percentages. Researchers have used various software applications to perform bibliometric analysis; VOSviewer used for this study.

Why VOSviewer? How does it Work?

Unlike programs that generate relatively restricted maps (such as SPSS and Pajek), VOSviewer was designed to create more detailed and wide-ranging bibliometric maps (Van Eck & Waltman, 2010). An understanding of VOSviewer terminology is necessary to grasp the working principles of the program; thus, an example based on Van Eck and Waltman's (2010) instructional manual is provided here. In **Figure 1**, there are circles with labels and links that connect them. These labels differ according to the type of analysis conducted; they may include author names for co-authorship analysis or keywords for co-occurrence analysis. Assume that the given map is part of a

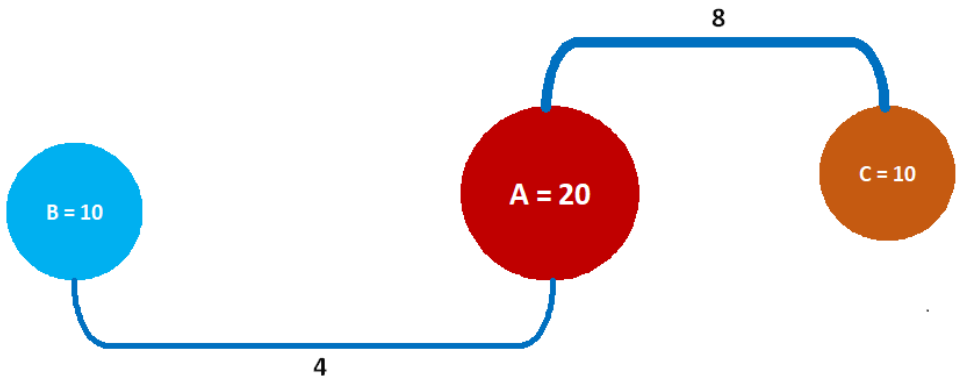

Figure 1. Working Principle of Vosviewer.

keyword analysis. Along with the keywords on the diagram, the frequency of occurrence is also indicated. The value next to the A keyword means that this keyword was encountered 20 times in the analysis. Suppose that the keywords B (blue) on the left and C (red) on the right are also seen 10 times. These frequencies are represented in the analysis program both by the size of the circles and the size of the labels. Thus, the circle and label for the A keyword are twice as big as those for the others.

The values of the links provide another important element for interpretation. The value "8" between the keywords A and C means that those two keywords are used together 8 times. Similarly, the value "4" represents the frequency of common use of the A and B keywords in the same study. In the analysis, these components, called link strengths, are shown in bold in proportion to the values they receive. The relative distance between the two objects also indicates these linkages. The link strength of the A keyword with the B keyword is 4, while the A keyword's link strength with the C keyword is 8. Therefore, in inverse proportion to these values, the distance between A and B is twice the distance between A and C.

Another key term is total link strength (TLS). TLS represents the total number of times the keyword is used together with all other keywords. In this case, while the TLS value of the A keyword is "12" (4 from A-B and 8 from A-C), and the keywords B (only A-B=4) and C (only A-C=8) are only related to A, their total link strength values are equal to their link strength values. Considering that the example given in the figure is only one part of a very large map, VOSviewer calculates the values of link strength for each of the keywords and total link strength for the other keywords, before grouping the concepts according to these linkages by arranging keywords that are frequently used with each other closely together and separating them from other

keywords that are less frequently connected. These infrastructures, called clusters (represented by blue and red colors in the example), are determined by calculating keywords' total link strengths with each other. When the program generates clusters, it includes the group with the higher TLS value of the relevant keyword. Thus, we can say that the total link strength of the B keyword with the keywords in the blue cluster is more than that of the keywords it is linked to in the red group. Van Eck and Waltman's (2010) manual provides a more detailed explanation of this mechanism.

Selection of Sources and Data Analysis

The analysis procedure consisted of two phases (see **Figure 2**). The first phase involved selecting the data sources, while the second phase included the analysis and interpretation of the data.

During the first phase, data was obtained using the Web of Science (WoS) database. WoS provided all the bibliometric data required for this analysis. In addition, this source was preferred because it works in harmony with the VOSviewer software. As depicted in **Figure 2**, we followed the process recommended by Moher et al. (2009) when selecting the data sources (Phase 1). The first step of this phase involved the initial identification of the records through a basic search in WoS. To execute this search, the *Journal of Research in Science Teaching* was entered into the "publication name" tab, to limit the query to studies in this journal. For the purposes of the study, "2000–2020" was chosen as the time span. A total of 1218 documents were obtained as a result. In the second step (screening), these documents were reviewed and all proceedings papers (13), corrections (5), and editorial materials (104) were excluded. After a total of 122 studies were eliminated, all remaining documents were reviewed in the third step (eligibility) for duplication and erroneous sources. After it was determined that there were no errors, a total of 1096 studies were included in the study sample. Thus, the final search phrase used in the Web of Science to gather the data for this study on February 12, 2021 was as follows:

PUBLICATION NAME: ("journal of research in science teaching") Refined by: [excluding] DOCUMENT TYPES: (PROCEEDINGS PAPER OR CORRECTION OR EDITORIAL MATERIAL) Timespan: 2000-2020. Indexes: SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, BKCI-S, BKCI-SSH, ESCI.

The second phase of data analysis began with descriptive analyses in WoS's analysis tab using frequencies and percentages. General insights were provided by visualizing the document types (e.g., review or research article) of the publications in JRST, the number of articles published by year, and the countries and universities of the publishing authors. In the second step, which involved bibliometric analysis for identifying the intellectual structure

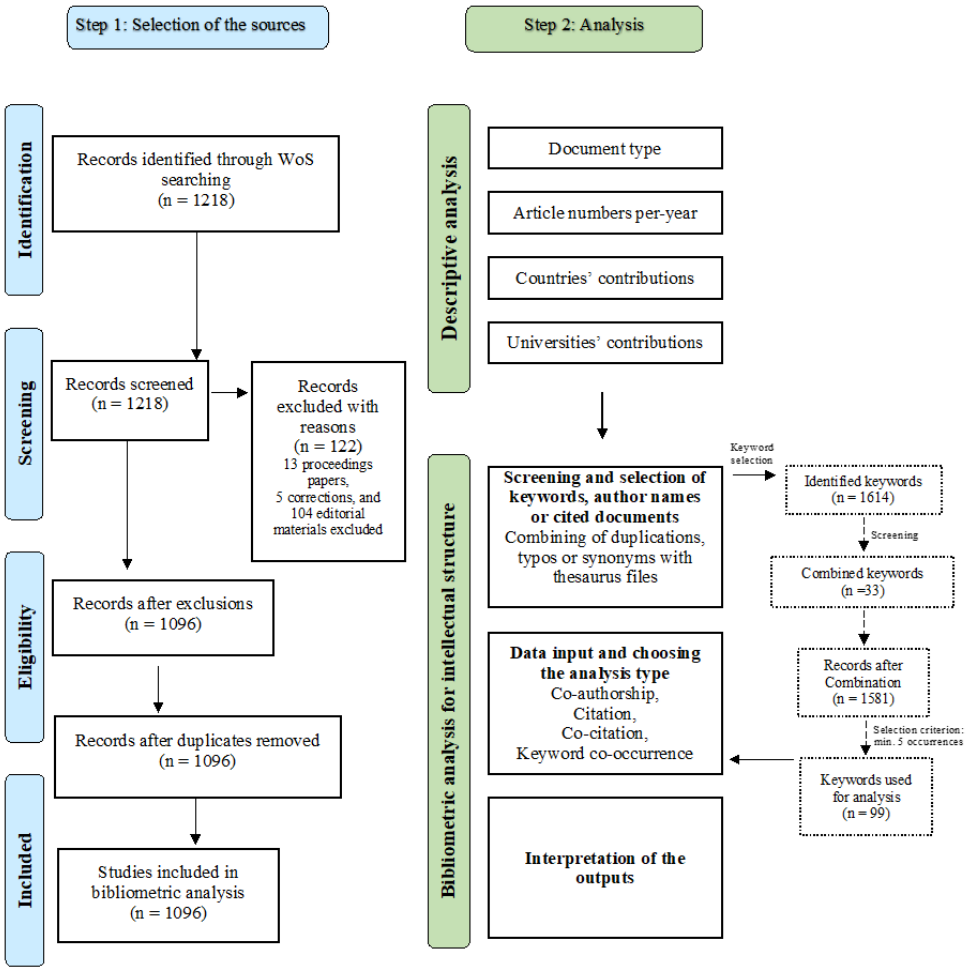

Figure 2. Selection of the Sources and Analysis.

of the journal, the previously downloaded data from the 1096 publications were transferred to VOSviewer for closer analysis. This process began with selection and screening of the keywords and author names. Since the software tries to create patterns using all the data during these analyses, it was important to first debug and correct any potential errors in the data. Thesaurus text files were used to prevent typos or redundant entries from causing unnecessary repetition in the results. For example, similar notations representing the same person or keyword in the WoS database, such as authors "Krajcik, J" and "Krajcik, JS," or keywords "socio-scientific issues" and "socioscientific issues" were combined.

Though the extraction logic employed in author and keyword analysis is similar, non-systematic keyword selection process is provided here as

an example. As seen in **Figure 2**, the studies included in the data set contained 1,614 author keywords. Keyword screening revealed that 33 of these author keywords had similar representations, where they were paired with others in the study that had the same meaning but were worded differently by the authors. For example, keyword combinations (that are not open to interpretation) such as "learning progressions" and "learning progression" or "nature of science" and "nature of science (NOS)" were made. This data cleaning process narrowed the number of keywords to 1,581. Next, the software needed to be told which keywords to examine. When all data was used at the same time, a vastly complicated map with 1581 keywords was created. To create a simpler map, keywords that were used fewer than five times were eliminated, to narrow the keywords to the most established concepts in the field of science education. This yielded the 99 most frequently used keywords, which were then analyzed.

This study utilized bibliometric analysis parameters such as citation (for authors and documents), co-citation, co-authorship, and co-occurrence (Van Eck & Waltman, 2010). At the conclusion of data analysis, the two researchers, who are experts on bibliometry, separately examined the maps generated by VOSviewer to make the final inferences.

The results of the data analysis are presented in two sections, each corresponding with one of the study's guiding research questions: the *descriptive analysis of the journal and intellectual structure of the journal* (following the categories described by Hallinger, 2020). The elements included in the descriptive analysis are outlined above. The second section presents an analysis of the journal's intellectual structure. In this study, "intellectual structure" refers to a journal's research traditions, interdisciplinary structure, and influential research subjects, as well as the pattern of relations among them (Zupic & Cater, 2015). According to Ramos‐Rodríguez and Ruíz‐Navarro (2004), frequently cited authors and documents have a greater influence on the field than those less frequently cited. Identifying the most influential authors and articles in a journal might therefore give insight into the journal's intellectual focus. To identify these influential authors, co-authorship analysis was performed in VOSviewer to identify the document numbers, link strengths, and TLS values of the authors. Citation counts were also taken directly from WoS to identify the most influential documents. The date when the study was published online was considered when calculating the average number of citations.

Co-citation analysis reveals publications that are cited together in the same study (Hallinger, 2020). Similarly, examining the co-citations found in a study helps researchers make inferences about the focus of that study. Co-citation analysis typically reveals studies with similar content, which can be used as an important data source for estimating the focus of studies in a particular field (Díez-Martín et al., 2021; Ramos-Rodríguez & Ruíz-Navarro,

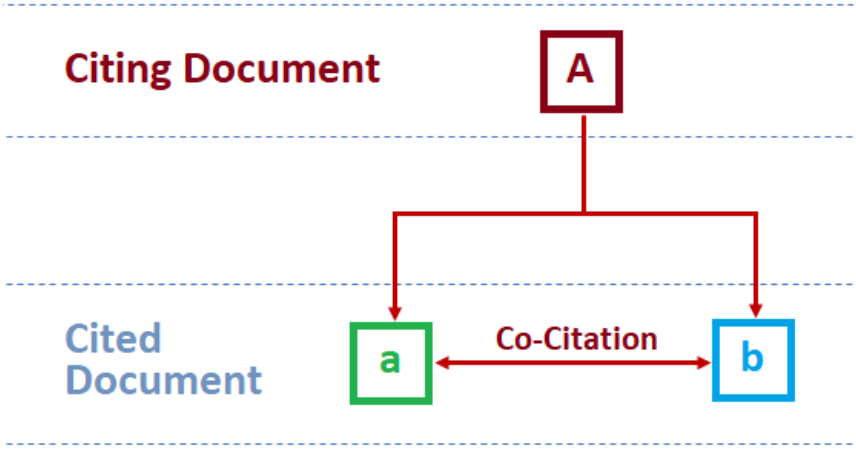

Figure 3. Representation of Co-Citation.

2004). **Figure 3**, designed by Vogel and Güttel (2013, p. 429), illustrates co-citation analysis of citing document A and cited documents a and b; thus, the number of times a and b are included in the reference list of the same document is calculated as their co-citation number.

Co-occurrence (keyword) analysis can also be used to identify a journal's intellectual structure. We employed author keywords for co-occurrence in this study by calculating the number of times these keywords were used both individually and together with other keywords. Co-occurrence analyses can provide researchers with accurate and reliable results about the topical foci in a journal or field (Gümüş et al., 2020). Consequently, combining co-authorship, citation count, co-citation and co-occurrence analyses enabled us to develop a big picture understanding of the JRST's topical patterns and intellectual structure over the last 20 years.

Study Limitations

This study aimed to illustrate the current trends in science education by analyzing the bibliometric data of the JRST from the past 20 years. However, it is important to highlight key limitations of this study's approach before interpreting its results. The most important limitation of this study involves the decisions made when selecting the keywords. As previously noted, only spelling issues or variations in the authors' notational preferences considered when deciding which keywords to combine. Even though several keywords may appear to represent the same meaning, all relevant research must be

thoroughly analyzed before making a merging decision, since it is difficult to discern the authors' intent behind the keywords they chose to use (Zupic & Cater, 2015). As Gümüş et al. (2020) explain, the content of the studies cannot be examined in detail when working with such a large data set; thus, a researcher cannot determine the true intentions of the authors or studies in question. For example, the keyword "African American" was not included in the analyses since it was only used once, and therefore did not meet the criteria for inclusion in this study (at least five references). We therefore needed to examine the study itself to determine whether it should be combined with the "race" keyword. However, even reviewing such studies in order to proceed with keyword merging could fall prey to researchers' subjective opinions; thus, to minimize the potential of bias, we limited merges to spelling preferences only. Since the analysis program works on a single combination basis, it will be up to the researcher's decision whether to combine the keyword "African American" with "equity" or "race". Considering the working principle of bibliometric analysis, including eliminated keywords in the analysis could result in changes in the maps. As a result, one of the major limitations of the present study was that these potentially relevant keywords were not included.

Another limitation involves the keyword pool that journals provide when researchers submit their manuscripts. The JRST, like some other journals, asks authors to choose keywords from a pool for the review process when they first submit a manuscript. Although journals enable authors to add their own keywords after review, authors may choose to stick to keywords from the pool. This could lead to the frequent use of similar keywords in studies published in the journal.

Finally, because of the quantitative nature of this study, it avoids making some qualitative interpretations. It is obvious, for example, that inferring "influential" documents or authors in a field based on citation numbers is a significant limitation. In this context, it is important to remember that qualitative interpretations of the influential authors or documents in the JRST could limit the replicability and generalizability of this study's findings. With these limitations in mind, it is still reasonable to assert that this study offers meaningful implications for interpreting broad trends in the field of science education.

Findings

General Descriptive Analysis of JRST between 2000 and 2020

Table 1. Distribution of the Document Types.

Document types	Records	% of 1,096
Research article	1,069	97.54
Review article	27	2.46

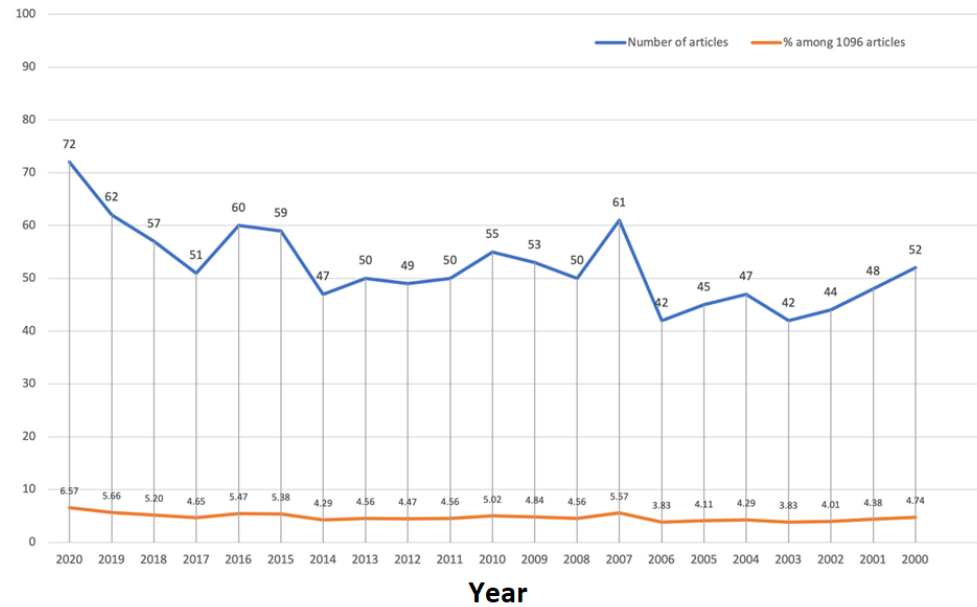

Figure 4. Annual Number of Articles Published in the JRST.

Table 1 shows the types of documents included in the analysis. Of the 1096 studies analyzed, 1069 were research articles and 27 were review articles. When the data were obtained, 15 of the studies were in the early access process.

Figure 4 shows the annual number of articles published in the JRST over the last two decades, as well as their percentage distribution based on WoS data. According to WoS data, the greatest numbers of studies were published in 2020 (72; 6.57%). However, since 15 of these studies were in the early access stage, this annual number appears high. The journal's web-site indicates that 57 research and review articles were published in 2020. On the other hand, 2003 and 2006 saw the lowest number of publications, with 42 articles (3.83%) each.

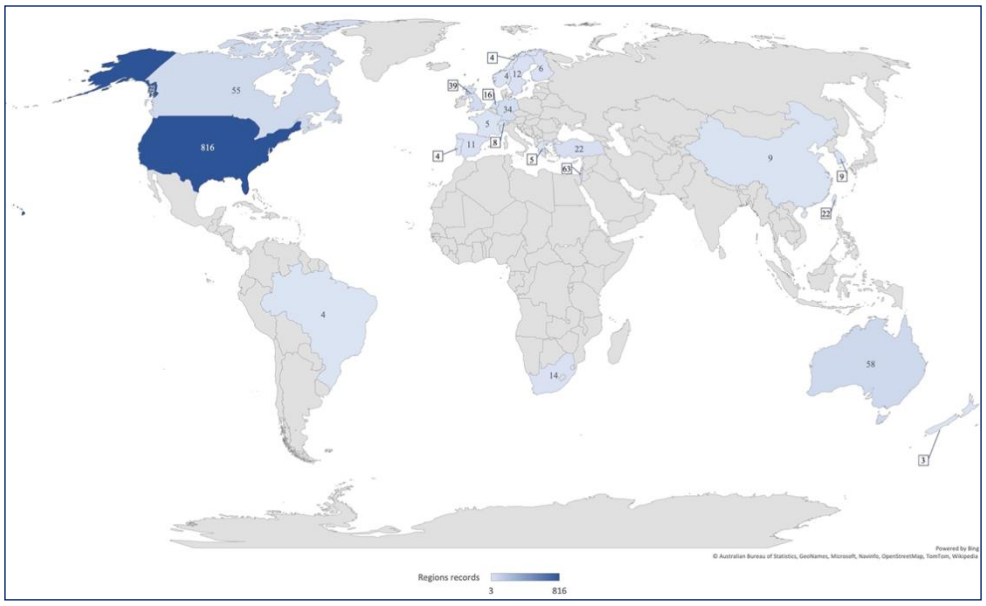

Figure 5. Distribution of Publications by Country.

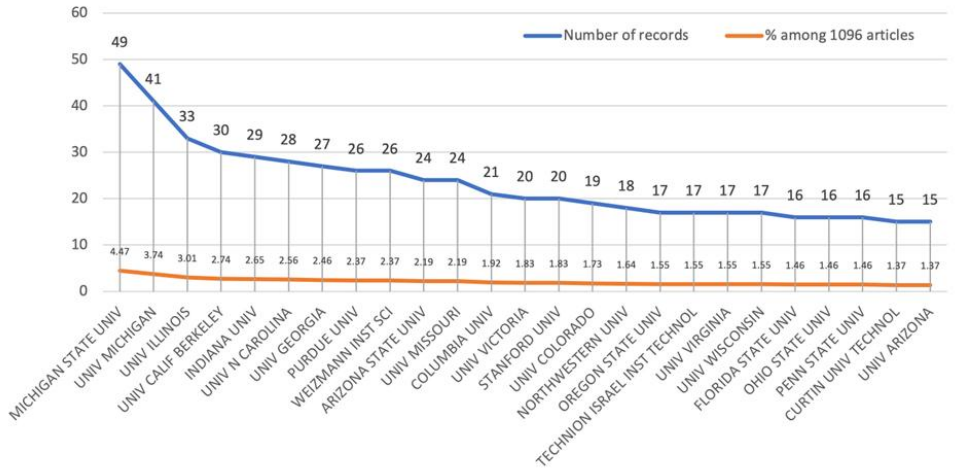

Figure 6. Distribution of Publications by Universities/Institutions.

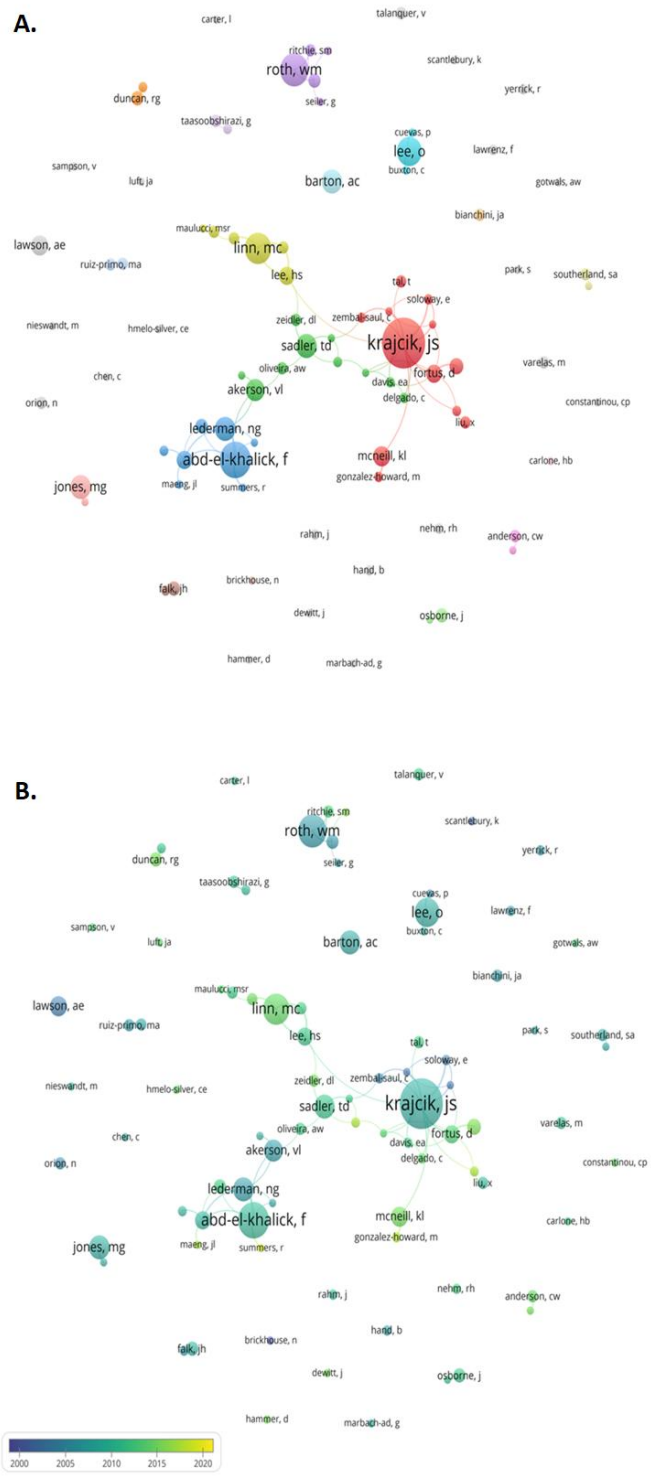

Figure 7. (A) VOSviewer Output for Co-Authorship Analysis. (B) VOSviewer Output for the Average Publication Years of the Authors.

Figure 5 identifies the countries where the studies in the dataset were conducted. This graphic, which depicts the 25 most referenced countries, shows that 816 (more than 70%) of the studies came from the United States, followed by Israel with 63 studies, Australia with 58, Canada with 55, and the UK with 39. Finally, Brazil (4), Norway (4), Portugal (4), and New Zealand (3) contributed the fewest studies among the top 25 countries. Countries shown in gray published fewer than three studies and were not among the top 25 countries.

Additional descriptive analysis was conducted to determine the authors' university affiliations. **Figure 6** shows the 25 universities that contributed the greatest number of studies to the journal during the 20-year period. Scholars from Michigan State University (49; 4.47%) contributed the most to the journal, followed by the University of Michigan with 41 studies (3.74%) and the University of Illinois with 33 studies (3.01%). Interestingly, 21 of the top 25 universities were in the USA. While Israel (the Weizmann Institute of Science and the Technion-Israel Institute of Technology) had two institutions on the list, Canada (the University of Victoria) and Australia (Curtin University of Technology) each had one.

Intellectual Structure of the JRST between 2000 and 2020

Co-authorship

Co-authorship analyses were conducted to identify the most productive researchers and research groups published in the JRST over the last 20 years. A VOSviewer visual illustrating this co-authorship analysis is presented in **Figure 7A**. A total of 2237 authors appeared in the analysis, with 86 authors having at least 4 publications. Although the authors who appear unconnected in the visual have at least 4 publications, they do not have co-authorship visuals due to their co-authors lacking at least 4 publications. The map shows several small groups, as well as four interconnected and dominant working groups. These clusters are shown on the map in green, red, yellow, and blue.

T.D. Sadler is the most influential researcher in the green cluster, with 12 papers. This green group establishes connections with other dominant groups, thereby acting as a unifying group, which is why it is located in the center of the map. This group has clearly established links with the yellow group through D.L. Zeidler and the blue group with V.L. Akerson. Sadler and colleagues focused their articles on socio-scientific issues, informal reasoning, and decision making. J.S. Krajcik is located in the center of the red cluster, another dominant group, with a total of 27 documents. Stud-

Table 2. LS and TLS of the Authors.

Author 1				Author 2				A1&2 LS
Name	DN	L	TLS	Name	DN	L	TLS	
Krajcik, J.S.	27	12	28	Soloway, E.	5	3	8	5
				Blumenfeld, P.C.	4	4	8	4
Abd-El-Khalick, F.	19	6	14	Lederman, N.G.	12	5	14	4
				Summers, R.	4	1	4	4
				Akerson, V.L.	11	4	7	2
Roth, W.M.	17	2	6	Tobin, K.	7	4	8	4
Linn, M.C.	16	3	10	Liu, O.L.	6	2	9	4
Sadler, T.D.	12	4	6	Zeidler, D.L.	7	2	3	3
McNeill, K.L.	10	2	7	Gonzales-Howard, M.	5	1	5	5
Fortus, D.	9	6	12	Vedder-Weiss, D.	8	1	4	4

***DN**: Document Number; **L**: Links; **TLS**: Total Link Strength; **LS**: Link Strength.*

ies in the red cluster tend to focus on project and inquiry-based classrooms. Beyond the red cluster, the map also indicates Krajcik's frequent collaborations with authors in the green cluster, making Krajcik the strongest link between the red and green groups. F. Abd-El-Khalick, located in the center of the blue cluster, has become one of the leading authors in terms of both productivity and partnerships, with 19 documents. This blue cluster indicates that Abd-El-Khalick's studies in partnership with N.G. Lederman, R.L. Bell, and R.S. Schwartz focused on nature of science (NoS) and scientific inquiry. Finally, M.C. Linn forms the center of the yellow group, with 16 documents. The studies of the yellow group are generally focused on assessment and dynamic visualization.

Additional influential working groups beyond these four dominant clusters are also pictured on the map. One of the most prominent was the violet group, which included W.M. Roth (17 documents) and colleagues. This group generally conducted studies on co-teaching, urban science education, and cultural diversity.

Table 2 shows the number of documents (DN) of the most influential authors who published in the JRST during the 20-year period, the number of different authors they worked with (L), and the number of times they collaborated with other authors in total (TLS). The last column of the table indicates the partnerships of the authors in the first and second columns (Link Strength: LS).

J.S. Krajcik stands out with 27 papers, collaborations with 12 separate authors, and 28 partnerships between 2000 and 2020. Krajcik collaborated most frequently with E. Soloway (5 times). Also prominent was F.

Table 3. Most Influential Documents of the JRST in the Last 20 Years.

	Title	Year	C	AVP
1	Views of nature of science questionnaire: Toward valid and meaningful assessment of learners' conceptions of nature of science. ***Lederman, N.G.; Abd-El-Khalick, F.; Bell, R.L.; Schwartz, R.S.***	2002	723	36.15
2	Enhancing the quality of argumentation in school science. ***Osborne, J.; Erduran, S.; Simon, S.***	2004	589	32.72
3	Understanding the science experiences of successful women of color: Science identity as an analytic lens. ***Carlone, H.B..; Johnson, A.***	2007	555	37
4	Inquiry-Based Science Instruction-What Is It and Does It Matter? Results from a Research Synthesis Years 1984 to 2002. ***Minner, D.D.; Levy, A.J.; Century, J.***	2010	550	45.83
5	Fostering students' knowledge and argumentation skills through dilemmas in human genetics. ***Zohar, A.; Nemet, F.***	2002	530	26.5
6	Informal reasoning regarding socioscientific issues: A critical review of research. ***Sadler, T.D.***	2004	446	24.78
7	Scientific literacy: Another look at its historical and contemporary meanings and its relationship to science education reform. ***DeBoer, G.E.***	2000	445	20.23
8	Developing a Learning Progression for Scientific Modeling: Making Scientific Modeling Accessible and Meaningful for Learners. ***Schwarz, C.V.; Reiser, B.J.; Davis, E.A.; Kenyon, L.; Acher, A.; Fortus, D.; Shwartz, Y.; Hug, B.; Krajcik, J.***	2009	443	34.08
9	Sources of science self-efficacy beliefs of middle school students. ***Britner, S.L.; Pajares, F.***	2006	401	25.06
10	Articulating communities: Sociocultural perspectives on science education. ***Lemke, J.L.***	2001	391	18.62
11	Professional development and reform in science education: The role of teachers' practical knowledge. ***van Driel, J.H.; Beijaard, D.; Verloop, N.***	2001	388	18.48
12	Influence of explicit and reflective versus implicit inquiry-oriented instruction on sixth graders' views of nature of science. ***Khishfe, R.; Abd-El-Khalick, F.***	2002	340	17
13	The effects of professional development on science teaching practices and classroom culture. ***Supovitz, J.A.; Turner, H.M.***	2000	334	15.18
14	Rethinking diversity in learning science: The logic of everyday sense-making. ***Warren, B.; Ballenger, C.; Ogonowski, M.; Rosebery, A.S.; Hudicourt-Barnes, J.***	2001	324	15.43
15	Facilitating Change in Undergraduate STEM Instructional Practices: An Analytic Review of the Literature. ***Henderson, C.; Beach, A.; Finkelstein, N.***	2011	309	28.09
16	Promoting understanding of chemical representations: Students' use of a visualization tool in the classroom. ***Wu, H.K.; Krajcik, J.S.; Soloway, E.***	2001	305	14.52
17	Influence of a reflective explicit activity-based approach on elementary teachers' conceptions of nature of science. ***Akerson, V.L.; Abd-El-Khalick, F.; Lederman, N.G.***	2000	301	13.68
18	Learning to teach science as inquiry in the rough and tumble of practice. ***Crawford, B.A.***	2007	289	19.27
19	Embracing the essence of inquiry: New roles for science teachers. ***Crawford, B.A.***	2000	281	12.77
20	In search of pedagogical content knowledge in science: Developing ways of articulating and documenting professional practice. ***Loughran, J.; Mulhall, P.; Berry, A.***	2004	279	15.5

Abd-El-Khalick with 19 documents, 6 collaborators, and 14 total collaborations, including 4 collaborations with Lederman and 4 collaborations with R. Summers. As a final example, M.C. Linn was also a prolific author, with 16 documents, 3 co-authors, and 10 total collaborations, including 4 collaborations with O.L. Liu.

Co-authorship analysis determined that the average publication dates of the researchers varied between 2000 and 2018 (see **Figure 7B**). In the graphic, the darker colored circles represent those studies published in earlier years, while yellow tones indicate more recent publication dates. N. Brickhouse (2000), K. Scantlebury (2002), and A.E. Lawson (2003) had older averages, while R. Summers (2018), M. Gonzales-Howard (2017), and K. Neumann (2016) contributed to the journal more recently.

Influential Documents

Next, the analysis identified the 20 documents published in the JRST over the past two decades that had the greatest impact (**Table 3**). Citations of these studies from articles in JRST and all other journals indexed in the WoS database as of the date of data acquisition were evaluated. The impact of documents can be evaluated in two ways: the first involves identifying the most cited documents in the years in question, while the second involves calculating the average number of citations the study received over the years. According to the first method, the most cited paper was "Views of nature of science questionnaire: Toward valid and meaningful assessment of learners' conceptions of nature of science" by Lederman et al. (2002). This study, which involves the VOSI scale—developed to determine the understanding of the nature of science—had 723 citations. The next most-cited paper was Osborne et al.'s (2004) "Enhancing the quality of argumentation in school science." This article, which is among the foundational studies on the use of argumentation in science classes, has been referenced by authors 589 times. With their study titled "Understanding the science experiences of successful women of color: Science identity as an analytic lens," Carlone and Johnson (2007) ranked third with 555 citations. This study has been the most prominent study of diversity and inclusion in science education in recent years.

Examining the average citations per year offers a different perspective. It is expected that older studies will receive more citations due to their longer shelf life. Therefore, assessing the average number of citations received per year allows us to make more reliable inferences about the effectiveness of a particular study in the field. In this context, the second and third studies in the top three are again Carlone and Johnson (2007) with 37 average citations and Lederman et al. (2002) with 36.15, while a paper titled "Inquiry-Based Science Instruction-What Is It and Does It Matter? Results from

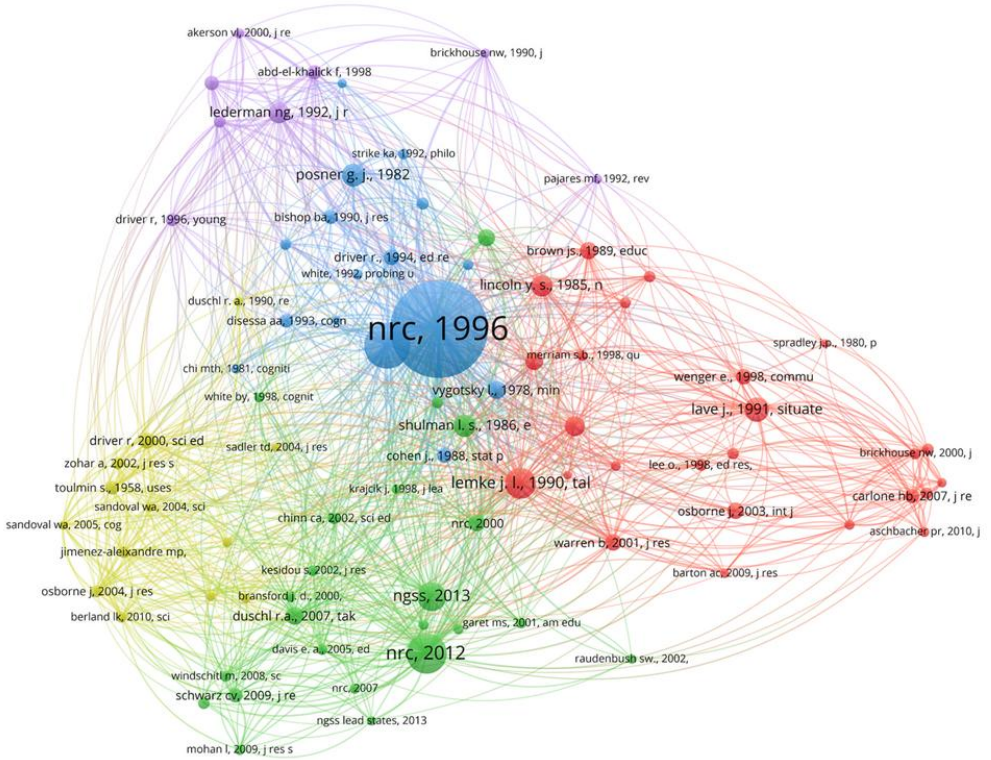

Figure 8. VOSviewer Output for Co-Citation Analysis.

a Research Synthesis Years 1984 to 2002" by Minner, Levy, and Century was the most prominent, with an average of 45.83 citations per year.

Co-citation

When conducting co-citation analysis of the 39,901 total references in the corpus of the present study, we selected studies with at least 25 references, to map a total of 85 studies (**Figure 8**). The WoS data includes only the first author of the cited document; thus, other authors are not presented on the map.

As depicted in **Figure 8**, five main clusters appeared during this phase of analysis. When looking at all the co-citation data, NRC (1996) (336 citations) and AAAS (1993) (148 citations) emerge as the most cited documents out of all the studies, and thus are in the center of the map. Since the blue cluster to which these studies belong is generally located in the center, it can be assumed that this cluster contains the field's most foundational documents. This group includes articles by G.J. Posner (1982), I. Vygotsky

(1978), T. Kuhn (1962), and R. Driver (1994) that played an important role in shifting the paradigm of science education. In addition to the centrally located blue cluster, the green cluster also represents shared thoughts, since it spreads to different points on the map. The most frequently cited document of the green group was published by the NRC (2012). In addition, the articles in this group by Next Generation Science Standards (2013), NRC (2000), R.A. Duschl (2007), and Shulman (1986, 1987) were also frequently cited and represent other basic studies of the field. The main difference from the blue cluster is that the green cluster mostly consists of studies published after 2000.

Three additional distinct clusters were identified, each clearly separated from the others. The first was the violet cluster at the top of the map, with N.G. Lederman (1992) at the center. The cluster, which includes additional documents by N.G. Lederman (2000 and 2002), as well as F. Abd-El-Khalick (1998 and 2000), N.W. Brickhouse (1990), and V.L. Akerson (2000), is mostly cited in studies centered around the Nature of Science (NoS).

Although it does not have a clear center, the studies in the yellow cluster are generally argumentation and reasoning oriented. This cluster includes documents by S. Toulmin (1958), R. Driver (2000), M.P. Jimenez-Aleixandre (2000), J. Osborne (2004), A. Zohar (2002), and T. Sadler (2004).

Finally, the studies in the red cluster mostly focus on inclusion in science education; thus, researchers working on issues such as equity, diversity, identity, and gender typically cite these documents. Examples include articles by H.B. Carlone (2004), N.W. Brickhouse (2000), and D. Holland (1998).

Table 4 shows the first authors of the most cited documents in the JRST from each cluster, along with their most frequently co-cited documents. NRC (1996) was most frequently cited with AAAS (1993), while NRC (2012) was most frequently cited with NGSS (2013), and Lederman (1992) was most frequently cited with Abd-El-Khalick (1998).

Co-occurrence Author Keywords

Of the 1581 total keywords included in the analysis, 99 had at least 5 occurrences. These 99 most frequent keywords were mapped, with a minimum cluster size of 15 for clearer reading of the results. As a result of the analysis, among the 99 keywords detected in the JRST between 2000 and 2020, 20 of the most frequently used keywords are presented in **Table 5**. The table also shows the clusters for the keywords, total link strength, and average publication year.

As seen in the table, science education, inquiry-based learning, and equity represented the most used keywords, with the strongest TLS. These

Table 4. Most Cited Documents by JRST Authors and Their Co-Citations.

Source 1				Source 2				S1&2 LS
Author Name	C	L	TLS	Author Name	C	L	TLS	
NRC, 1996	336	83	1226	AAAS, 1993	148	83	613	115
Lederman, N.G., 1992	63	67	373	Abd-El-Khalick, F., 1998	41	60	259	26
Driver, R., 2000	47	69	328	Zohar, A., 2002	35	64	267	21
NRC, 2012	127	81	594	NGSS, 2013	88	74	299	44
Lemke, J.L., 1990	96	78	432	Warren, B., 2001	49	64	258	15

***C**: Citations; **L**: Links; **TLS**: Total Link Strength; **LS**: Link Strength.*

Table 5. Most Seen Keywords and Descriptives.

Keywords	Cluster	Occurrences	Total Link Strength	Av. Pub. Year
Science Education	Red	82	172	2015
Inquiry-Based Learning	Green	66	141	2013
Equity	Red	43	109	2014
Secondary Science	Yellow	43	107	2012
Middle School Science	Red	41	94	2011
Chemistry Education	Yellow	41	77	2012
Nature of Science (Nos)	Yellow	40	81	2012
Professional Development	Green	39	83	2014
Physics Education	Red	37	89	2011
General Science	Red	35	89	2008
Assessment	Green	35	68	2014
Biology Education	Yellow	34	84	2011
Achievement	Red	32	75	2012
Science Teacher Education	Green	32	62	2013
Elementary Science	Blue	32	58	2013
Learning Progression	Green	32	46	2014
Curriculum Development	Green	31	83	2012
Teacher Education	Green	28	68	2014
Evolution	Green	28	55	2013
Socio-Scientific Issues	Yellow	27	50	2013

keywords—which have 172, 141, and 109 total link strengths, respectively—were the most used by researchers and consequently the most frequently associated with other keywords.

As represented in **Figure 9A**, the 99 most popular keywords were grouped under 4 clusters. The keywords in the blue, green, and red clusters are all clearly distinguished from other clusters. The yellow cluster, on the

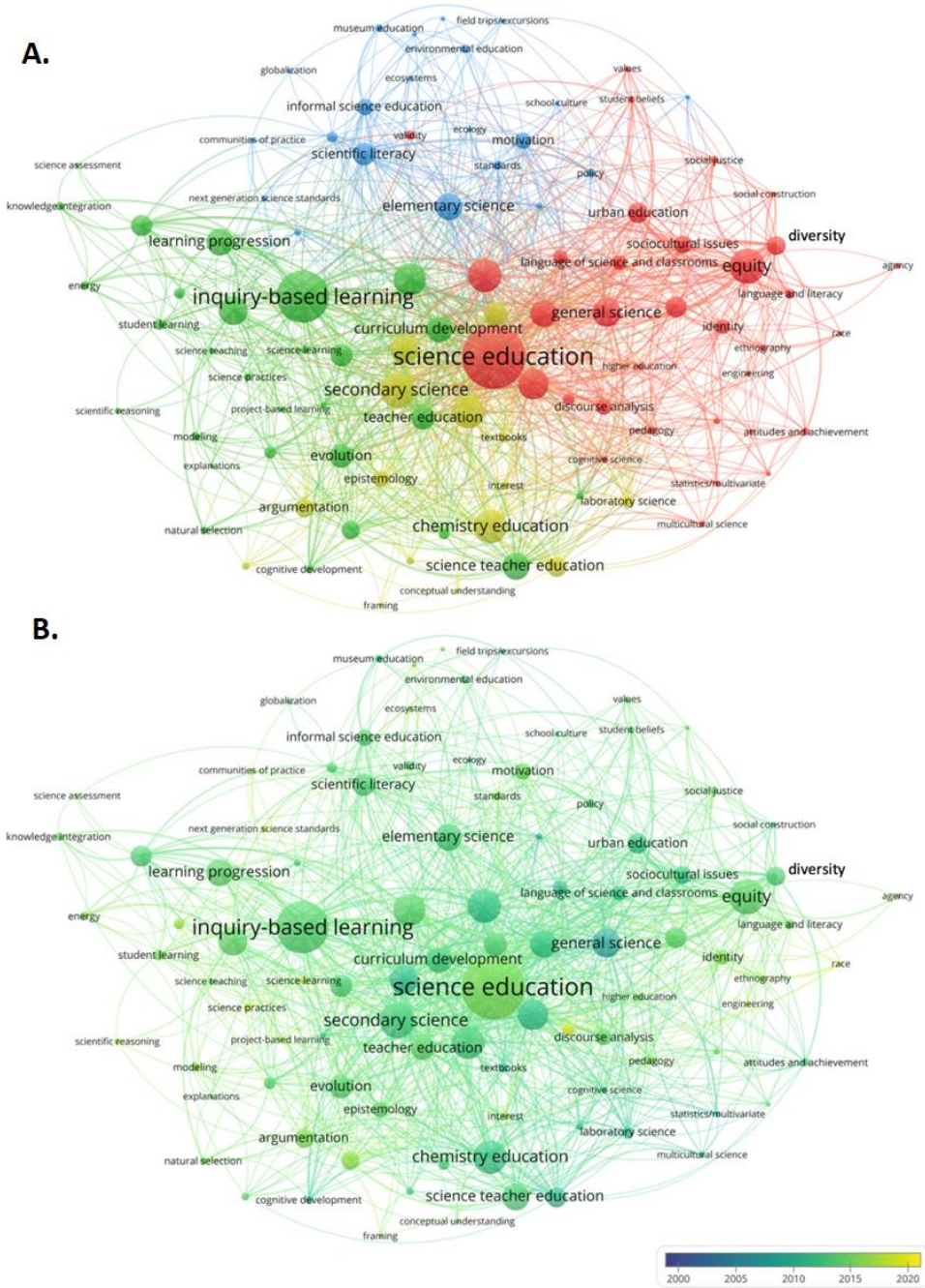

Figure 9. (A) VOSviewer Output for Co-Occurence Analysis. (B) VOSviewer Output for the Average Years of the Keywords.

Table 6. Link Strength of Most Used Keywords.

Item 1	Item 2	Link Strength
Equity	Diversity	10
	Science Education	7
	Socio-cultural issues	6
Inquiry-based learning	Curriculum development	10
	Technology education	10
	Professional development	7
Nature of Science (NOS)	Inquiry-based learning	7
	General science	6
	Socio-scientific Issues	6
Informal science	Museum Education	7

other hand, connects with all the other clusters. The science education keyword in the center of the red cluster also forms the center of the entire map. Most of the inclusive education keywords were found in this cluster, including equity (43 occurrences), gender (25), diversity (22), socio-cultural issues (20), identity (17), ethnography (6), race (5), multicultural science (7), urban education (24), social justice (8), and values (6).

In the green cluster, while inquiry-based learning (66 occurrences) was the central keyword, learning progression (32), conceptual change (26), evolution (28), misconceptions (13), science teacher education (32), pedagogical content knowledge (21), technology education (25), and assessment (35) were also typical agents of the cluster. Thus, the green cluster can be called a learning and teaching oriented cluster.

The blue cluster's keywords focus on informal science education. Scientific literacy (26 occurrences), informal science (19), museum education (8), environmental education (9), motivation (19), and field trips/excursions (5) are among the most frequently used words in this cluster.

Finally, the yellow cluster represents the basics of a new paradigm. This cluster is nested within the others, and thus collects concepts that reflect the paradigm shift in the field such as nature of science (40), epistemology (18), socio-scientific issues (27), and argumentation (22).

The frequencies of selected keywords in the map are shown in **Table 6**, which includes the most used keywords that represent each cluster. The keyword equity, which represents the red cluster, is frequently paired with the diversity (10), science education (7), and sociocultural issues (6) keywords in the same cluster. The inquiry-based learning keyword in the center of the green cluster, on the other hand, had 10 TLS with curriculum development and technology education and 7 TLS with professional development.

In the blue cluster, informal science was used 7 times with museum education.

Figure 9B shows the average years when the keywords were used between 2000 and 2020. While dark colors represent older years, light colors mean that the keywords were used more recently. Statistics/multivariate and general science were found to have the oldest average (2008) among the keywords. With an average publication year of 2019, the most recent keyword was STEM education. The average years in the inclusive (red) cluster were race, 2018; identity, 2015; agency, 2015; equity, 2014; and diversity, 2013. Average years in the learning and teaching (green) cluster were inquiry-based learning, 2013; learning progression, 2014; assessment, 2014; misconceptions, 2013; and conceptual change, 2013. In the blue cluster, the average years were 2013 for informal science education, scientific literacy, environmental education; 2011 for museum education; and 2009 for field trips/excursions. Finally, the average years in the yellow cluster were 2016 for pedagogical content knowledge, 2015 for argumentation, 2013 for socio-scientific issues, 2014 for epistemology, and 2012 for nature of science.

Discussion

When examining the overall image of the JRST from 2000 to 2020, one of the most striking findings is that more than 80% of the publication's authors hail from the United States, Australia, Canada, or the United Kingdom. Parallel to this result, 23 (92%) of the most prolific 25 universities that contributed are in the USA, Australia, or Canada. This result could be attributed to the leading role these countries have played in the paradigm change in science education. In these countries, the positivist-objectivist view of the nature of scientific knowledge is being replaced by a social constructivist epistemology (Irez & Han, 2011; Taylor et al., 1997). As a result, conceptual change research, a growing understanding of constructivism, and discussions on multicultural education have created changes in science education that began with the curriculum studies initiated in the post-Sputnik period and Kuhnian-inspired understandings from the 1970s (Matthews, 2004). Such large-scale educational reforms bring with them new conceptual frameworks, educational goals, and perspectives, which means a new world for researchers, teachers, students, and other stakeholders. Since paradigm shifts in a field tend to progress slowly, stakeholders who are resistant to change and hold onto previous paradigms can slow the pace of progress (Irez & Han, 2011). Considering that the paradigm shift in science education has a 50-year history, it is not surprising that the most popular studies included in this analysis tend to come from the first countries to adapt to this process of change. It is expected that the contributions of other countries will gradually increase; in fact, a review by Abd-El-Khalick et al. (2021) of JRST publica-

tions between 2015 and 2020 showed that non-US studies increased from 18% of the total articles in the journal in 2016 to 50% in 2019. The present study also confirmed the increasing trend of non-US studies over the past 20 years.

As stated previously, the co-authorship, influential documents, co-citation, and co-occurrence analyses provided important evidence about the dominant "schools of thought" within science education. Schools of thought, also referred to as "intellectual structures," represent the ideas and practices that dominate a field. This study concluded that although many authors have contributed to the JRST, certain authors came to the fore and contribute to the focus of the journal through their fields of study and influential publications. As stated in the findings section, J.S. Krajcik (project and inquiry-based classrooms), T.D. Sadler (socio-scientific issues, informal reasoning, and decision making), M.C. Linn (assessment and dynamic visualization), and N.G. Lederman and F. Abd-El-Khalick (nature of science and scientific inquiry) were among the most prolific researchers during the two-decade period. These authors not only have more publications than the other scholars published in the journal—they also worked with many other researchers, demonstrating a strong record of collaboration in their respective fields. Their working groups also connected with other groups, indicating that they frequently communicate and interact with the science education community. Additionally, W.M. Roth (co-teaching, urban science education, and cultural diversity) has been a prominent author independent of other working groups. The isolation of W. M. Roth and his working group from others can be read as a sign that these domains are not yet connected, which provides a critical gap for future work in this area.

The analysis of the most influential documents in the journal revealed that researchers most frequently referred to three domains of study: nature of science (Lederman et al., 2002), argumentation (Osborne et al., 2004), and science identity (Carlone & Johnson, 2007). The topic with the highest average of citations was scientific inquiry (Minner et al., 2010). Additional influential areas included socio-scientific issues (Sadler, 2004), sociocultural perspectives (Lemke, 2001) and scientific modeling (Schwarz et al., 2009). The productivity and citations of these documents confirm that they exemplify the trends within this field and, moreover, that they play an important role in shaping these trends (Pasadeos et al., 1998).

In co-citation analysis, documents that are cited together typically represent similar perspectives or philosophies. Thus, the close relations that emerge in these analyses can also give researchers messages about the intellectual structures that shape and drive the field. A similar condition, co-occurrence, is visualized through keyword analysis. Both the frequency and co-occurrence of keywords provide strong evidence of this intellectual structure (Hallinger, 2020). In the present study, three distinct school of thought groups emerged in co-citation analyses: NOS and scientific inquiry, argu-

mentation, and inclusive science education. Likewise, when the keywords were examined, three additional groups stood out: teaching and learning, informal science education, and inclusive science education.

The combined results of these analyses demonstrate that the researchers publishing in the JRST focused on two key questions over the past 20 years: "Which science teaching methods and strategies are most effective?" and "What can be done to make science teaching more inclusive?" This result echoes the findings of Concannon et al. (2020), who stated that schools of thought centered around fostering students' depth of knowledge of science and how it works have steadily strengthened over the last 30 years. As seen in the present study, the recent emergence of the STEM keyword in the literature represents a similar philosophy that has been fostered by these schools of thought.

Another school of thought contends that science education should be designed to include traditionally underrepresented minority groups. The science education community has embraced the mission of preparing a classroom environment that considers all these differences (Carlone, 2004). The constructivist approach to science education states that learners come to class with different prior knowledge, understanding, and cultural backgrounds—all of which are essential to creating educational experiences. These basic assumptions of the constructivist paradigm have led to the adoption of more inclusive education approaches (Matthews, 2002). As previously mentioned, recent popular topics in the JRST, such as STEM, appear to align well with inclusive education. In their analysis of studies on inclusive science education, Comarú et al. (2021) reported that STEM was the most used subject. Thus, strategies and practices from a constructivist approach—such as inquiry-based teaching, argumentation, socio-scientific issues, and STEM—can be employed to create more inclusive science classrooms. This inference leads us to conclude that these trends in science teaching should naturally lead researchers and practitioners to inclusive education. Our findings indicate that the JRST has paid special attention to the studies on inclusive science teaching and learning over the past two decades. Several notable efforts have pushed this issue into the spotlight, including a special issue, titled "Globalization in Science Education," published in 2011. This issue focused on "building closer international cooperation with a particular emphasis on valuing and keeping cultural diversity" (Chiu & Duit, 2011, p. 553). Furthermore, a virtual issue project directed by Atwater (2011) centered on studies published in the JRST between 1980 and 2010 about multicultural science education, equity, and social justice. After evaluating 233 total articles on these topics, reviewers (12 science educators) for the issue selected the 9 most compelling studies to highlight for today's science education community. As shown in the previous sections, the occurrence of keywords such as race (avg. year 2018), identity (avg. year 2015), equity (avg. year 2014), and

diversity (avg. year 2013) increased after these two special issues. Lastly, the journal's interest in inclusive science education is also supported by another special issue call titled "Community-driven: Evidence of and science implications for equity, justice, science, and participation," announced in April 2021 (Ballard et al., 2021). This call signals continued interest in promoting "equity in science and science education," which is also reflected through our bibliometric analysis of the JRST.

As previously stated, the difficult and time-consuming process of a paradigm shift in a field typically follows a set of natural stages. The first of these steps, as in all intellectual changes, involves identifying and speaking aloud the issue before change can be made. Since knowing something and doing something are two hugely different things (Pedretti & Hodson, 1995), it is critical that perceptions on the subject change first, both on an individual and community level (Levitt, 2002). This study shows that the science education community is trying to change perceptions on this subject; however, the field must also shift the focus of promoting equity in science education beyond mere rhetoric and towards concrete actions to build inclusive practices and structures in communities, schools, and the academy. As evident in the co-occurrence analysis, although the inclusive science education cluster has a significant place in the map, it is limited by its location at the periphery. It is critical that these keywords move to a central position just like the yellow cluster—that is, forming a fundamental philosophy that shapes all other study subjects. Indeed, this movement is critical not only for science education research, but also for understanding the "other" identities of us as citizens of the world (Mutegi et al., 2019).

Since many articles in the JRST have focused on empowering traditionally underrepresented students, teachers, and researchers in the field, it is worth considering why many of the most influential studies in the field come from white men. When the loudest voices speaking about an injustice related to identity do not belong to individuals who hold that identity, it signals a level of "invisibility" (Mutegi, 2013) for members of that community. For example, Avraamidou (2022) emphasized that school structures and culture can be alienating and intimidating for women. When racial disparities compound the difficulties that women face when attempting to reach the top of their profession (O'connor & Irvine, 2020), it creates a double bind for women of color (Nguyen et al., 2021). As Carlone and Johnson (2007) stated, these issues center around the academic world's "recognition" of gender and racial identity. In an ideal world, all different identities would be "visible" and recognized by the academy (Hughes et al., 2021). The gradual filtration of stereotypes and discrimination based on identity, which begins in early childhood, has since manifested itself in an academic social structure dominated by white males.

The inadequacy of pre-college science and math education for people of color, according to Russell and Atwater (2005), is another source of this inequality, which in turn influences college major and career choices for these minoritized groups. Variables such as other students, teachers, the school's psychosocial learning environment, and the curriculum have an impact on the science learning of any underrepresented group (Atwater, 2000). A social constructivist understanding of learning holds power to address these issues, since it reveals how differences are reflected in learning in every sense.

Unfortunately, solely eliminating disparities in science and math courses is insufficient. As Mutegi (2013) writes, all types of discrimination should be perceived as a component of a much larger system of oppression (e.g., systemic racism), and such a system can only be addressed through a total shift in perceptions. Thus, studies investigating how social perceptions of markers of difference impact pre-college science education (such as Mutegi's 2013 study of African-American students) or interrogating the recognition and hierarchy of these identities in the science classroom (see Carlone & Johnson, 2007) are critical. Additionally, we should reflect on how teachers, academics, parents, and other stakeholders render these different identities "invisible" and discourage or prevent minoritized students (Mutegi, 2013) from pursuing science-related careers as a result. Finally, raising consciousness around the effects of microaggressions will help create a more equitable learning environment for students from minoritized groups (Mutegi et al., 2019).

To conclude, this study analyzing the publications of the JRST provides clues about the construction of scientifically literate societies, which represents the ultimate goal of science education. The image of the last two decades of the JRST demonstrates that, while great strides have been made in building science literacy, these advancements are insufficient if they do not involve all segments of society. The COVID-19 pandemic has cruelly demonstrated that a significant portion of the population remains scientifically illiterate, which has posed massive problems in mitigating the spread of disease. The only way to deal with a crisis like this is to take collective action. When this context is considered in conjunction with this study's findings, it becomes clear how vital equality is to both education and society, since an unequitable learning environment cannot produce a proactive community capable of addressing systemic problems. In this way, while the cost of COVID-19 is human lives, the cost of racism and discrimination may be the "lives" of entire societies.

References

Abd-El-Khalick, F., Zeidler, D. L., & Niswander, E. C. (2021). Editors' report: Reflections for the Journal of Research in Science Teaching (2015–2020). *Journal of Research in Science Teaching*, 58(2):159-169. DOI: https://doi.org/10.1002/tea.21678

Abramo, G., D'Angelo, C. A., & Cicero, T. (2012). What is the appropriate length of the publication period over which to assess research performance? *Scientometrics*, 93(3):1005-1017. DOI: https://doi.org/10.1007/s11192-012-0714-9

Al, U., Soydal, İ., & Yalçın, H. (2010). Bibliyometrik özellikleri açısından bilig'in değerlendirilmesi. Bilig, 55, 1-20.

Anninos, L. N. (2014). Research performance evaluation: some critical thoughts on standard bibliometric indicators. *Studies in Higher Education*, 39(9):1542-1561. DOI: https://doi.org/10.1080/03075079.2013.801429

Assefa, S. G., & Rorissa, A. (2013). A bibliometric mapping of the structure of STEM education using co-word analysis. *Journal of the American Society for Information Science and Technology*, 64(12):2513-2536. DOI: https://doi.org/10.1002/asi.22917

Atwater, M. M. (2000). Equity for Black Americans in precollege science. *Science Education*, 84(2):154-179. https://doi.org/10.1002/(SICI)1098-237X(200003)84:2<154::AID-SCE2>3.0.CO;2-R

Atwater, M. M. (2011). Significant science education research on multicultural science education, equity, a social justice. *Journal of Research in Science Teaching*, 49(1):O1-O5. DOI: https://doi.org/10.1002/tea.20453

Avraamidou, L. (2022). Identities in/out of physics and the politics of recognition. *Journal of Research in Science Teaching*, 59(1):58-94. DOI: https://doi.org/10.1002/tea.21721

Ballard, H. L., Barton, A. C., & Upadhyay, B. (2021). Call for papers Journal of Research in Science Teaching Special Issue Community-driven science: Evidence of and implications for equity, justice, science learning, and participation. *Journal of Research in Science Teaching*, 58(5):621-624. DOI: https://doi.org/10.1002/tea.21690

Budd, J. M., & Magnuson, L. (2010). Higher education literature revisited: Citation patterns examined. *Research in Higher Education*, 51(3):294-304. DOI: https://doi.org/10.1007/s11162-009-9155-6

Bybee, R. W. (1997). Achieving scientific literacy: From purposes to practices. Heinemann, 88 Post Road West, PO Box 5007, Westport, CT 06881.

Callon, M., Rip, A., & Law, J. (Eds.). (1986). Mapping the dynamics of science and technology: Sociology of science in the real world. Springer.

Carlone, H. B. (2004). The cultural production of science in reform-based physics: Girls' access, participation, and resistance. *Journal of Research in Science Teaching*, 41(4):392-414. DOI: https://doi.org/10.1002/tea.20006

Carlone, H. B., & Johnson, A. (2007). Understanding the science experiences of successful women of color: Science identity as an analytic lens. *Journal of Research in Science Teaching*, 44(8):1187-1218. DOI: https://doi.org/10.1002/tea.20237

Chiu, M. H., & Duit, R. (2011). Globalization: Science education from an international perspective. *Journal of Research in Science Teaching*, 48(6):553-566. DOI: https://doi.org/10.1002/tea.20427

Comarú, M. W., Lopes, R. M., Braga, L. A. M., Batista Mota, F., & Galvão, C. (2021). A bibliometric and descriptiveanalysis of inclusive education in science education. *Studies in Science Education*, 57(2):241-263. DOI: https://doi.org/10.1080/03057267.2021.1897930

Concannon, J. P., Brown, P. L., Lederman, N. G., & Lederman, J. S. (2020). Investigating the development of secondary students' views about scientific inquiry. *International Journal of Science Education*, 42(6):906-933. DOI: https://doi.org/10.1080/09500693.2020.1742399

Diem, A., & Wolter, S. C. (2013). The use of bibliometrics to measure research performance in education sciences. *Research in Higher Education*, 54(1):86-114. DOI: https://doi.org/10.1007/s11162-012-9264-5

Díez-Martín, F., Blanco-González, A., & Prado-Román, C. (2021). The intellectual structure of organizational legitimacy research: a co-citation analysis in business journals. *Review of Managerial Science*, 15(4):1007-1043. DOI: https://doi.org/10.1007/s11846-020-00380-6

Dogan, O. K. (2021). Methodological? Or dialectical? Reflections of scientific inquiry in biology textbooks. *International Journal of Science and Mathematics Education*, 19(8):1563-1585. DOI: https://doi.org/10.1007/s10763-020-10120-7

Donthu, N., Kumar, S., Mukherjee, D., Pandey, N., & Lim, W. M. (2021). How to conduct a bibliometric analysis: Anoverview and guidelines. *Journal of Business Research*, 133:285-296. DOI: https://doi.org/10.1016/j.jbusres.2021.04.070

Earp, V. J. (2010). A bibliometric snapshot of the journal of higher education and its impact on the field. *Behavioral & Social Sciences Librarian*, 29(4):283-295. DOI: https://doi.org/10.1080/01639269.2010.521034

Gholampour, S., Noruzi, A., Gholampour, B., & Elahi, A. (2019). Research trends and bibliometric analysis of a journal: Sport management review. *Webology*, 16(2):223-241. DOI: http://www.webology.org/2019/v16n2/a200.pdf

Güneş, E., Üstündağ, M. T., Yalçın, H., & Safran, M. (2017). Investigating educational research articles (1980-2014) in terms of bibliometric indicators. *International Online Journal of Educational Sciences*, 9(1):101-117. DOI: http://dx.doi.org/10.15345/iojes.2017.01.008

Gümüş, S., Bellibaş, M. Ş., Gümüş, E., & Hallinger, P. (2020). Science mapping research on educational leadership and management in Turkey: A bibliometric review of international publications. *School Leadership & Management*, 40(1):23-44. DOI: https://doi.org/10.1080/13632434.2019.1578737

Hallinger, P., & Kovačević, J. (2019). A bibliometric review of research on educational administration: Science mapping the literature, 1960 to 2018. *Review of Educational Research*, 89(3):335-369. DOI: https://doi.org/10.3102/0034654319830380

Hallinger, P. (2020). Science mapping the knowledge base on educational leadership and management from the emerging regions of Asia, Africa and Latin America, 1965–2018. *Educational Management Administration & Leadership*, 48(2):209-230. DOI: https://doi.org/10.1177/1741143218822772

Hughes, R., Schellinger, J., & Roberts, K. (2021). The role of recognition in disciplinary identity for girls. *Journal of Research in Science Teaching*, 58(3):420-455. DOI: https://doi.org/10.1002/tea.21665

Irez, S., & Han, C. (2011). Educational Reforms as Paradigm Shifts: Utilizing Kuhnian Lenses for a Better Understanding of the Meaning of, and Resistance to, Educational Change. *International Journal of Environmental and Science Education*, 6(3):251-266. https://files.eric.ed.gov/fulltext/EJ959419.pdf

Laengle, S., Merigó, J. M., Miranda, J., Słowiński, R., Bomze, I., Borgonovo, E., ... & Teunter, R. (2017). Forty years of the European Journal of Operational Research: A bibliometric overview. *European Journal of Operational Research*, 262(3):803-816. DOI: https://doi.org/10.1016/j.ejor.2017.04.027

Laengle, S., Modak, N. M., Merigó, J. M., & De La Sotta, C. (2018). Thirty years of the International Journal of Computer Integrated Manufacturing: a bibliometric analysis. *International Journal of Computer Integrated Manufacturing*, 31(12):1247-1268. DOI: https://doi.org/10.1080/0951192X.2018.1529434

Leary, H., & Walker, A. (2018). Meta-analysis and meta-synthesis methodologies: Rigorously piecing together research. *TechTrends*, 62(5):525-534. DOI: https://doi.org/10.1007/s11528-018-0312-7

Levitt, K. E. (2002). An analysis of elementary teachers' beliefs regarding the teaching and learning of science. *Science Education*, 86(1):1-22. DOI: https://doi.org/10.1002/sce.1042

Matthews, M. R. (2002). Constructivism and science education: A further appraisal.

Journal of Science Education and Technology, 11(2):121-134. DOI: https://doi.org/1059-0145/02/0600-0121/0

Matthews, M. R. (2004). Thomas Kuhn's impact on science education: What lessons can be learned? *Science Education*, 88(1):90-118. DOI: https://doi.org/10.1002/sce.10111

Merigó, J. M., & Yang, J. B. (2017). A bibliometric analysis of operations research and management science. *Omega*, 73:37-48. DOI: https://doi.org/10.1016/j.omega.2016.12.004

Moed, H. F. (2005). Statistical relationships between downloads and citations at the level of individual documents within a single journal. *Journal of the American Society for Information Science and Technology*, 56(10):1088-1097. DOI: https://doi.org/10.1002/asi.20200

Moher, D., Liberati, A., Tetzlaff, J., Altman, D. G., Altman, D., Antes, G., & Tugwell, P. (2009). Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement (Chinese edition). *Journal of Chinese Integrative Medicine*, 7(9):889-896. DOI: https://doi.org/10.7326/0003-4819-151-4-200908180-00135

Mutegi, J. W. (2013). "Life's first need is for us to be realistic" and other reasons for examining the sociocultural construction of race in the science performance of African American students. *Journal of Research in Science Teaching*, 50(1):82-103. DOI: https://doi.org/10.1002/tea.21065

Mutegi, J. W., Sorge, B., Fore, G. A., & Gibau, G. S. (2019). A tale of two camps: A mixed methods investigation into racially disparate outcomes in a nanotechnology research experience. *Science Education*, 103(6):1456-1477. DOI: https://doi.org/10.1002/sce.21548

Narin, F. (1976). Evaluative bibliometrics: The use of publication and citation analysis in the evaluation of scientific activity (pp. 206-219). Cherry Hill, NJ: Computer Horizons.

Nguyen, T. H., Gasman, M., Washington Lockett, A., & Peña, V. (2021). Nguyen, T. H., Gasman, M., Washington Lockett, A., & Peña, V. (2021). Supporting Black women's pursuits in STEM. *Journal of Research in Science Teaching*, 58(6):879-905. DOI: https://doi.org/10.1002/tea.21682

O'Connor, P., & Irvine, G. (2020). Multi-level state interventions and gender equality in higher education institutions: The Irish case. *Administrative Sciences*, 10(4):98. DOI: https://doi.org/10.3390/admsci10040098

Pasadeos, Y., Phelps, J., & Kim, B. H. (1998). Disciplinary impact of advertising scholars: Temporal comparisons of influential authors, works and research networks. *Journal of Advertising*, 27(4):53-70. DOI: https://doi.org/10.1080/00913367.1998.10673569

Pedretti, E., & Hodson, D. (1995). From rhetoric to action: Implementing STS education through action research. *Journal of Research in Science Teaching*, 32(5):463-485. DOI: https://doi.org/10.1002/tea.3660320505

Phelan, T. J. (2000). Bibliometrics and the evaluation of Australian sociology. *Journal of Sociology*, 36(3):345-363. DOI: https://doi.org/10.1177/144078330003600305

Pritchard, A. (1969). Statistical bibliography or bibliometrics. *Journal of Documentation*, 25(4):348-349.

Ramos-Rodríguez, A. R., & Ruíz-Navarro, J. (2004). Changes in the intellectual structure of strategic management research: A bibliometric study of the Strategic Management Journal, 1980–2000. *Strategic Management Journal*, 25(10):981-1004. DOI: https://doi.org/10.1002/smj.397

Reiss, M. J. (2020). Science Education in the Light of COVID-19. *Science & Education*, 29(4):1079-1092. https://doi.org/10.1007/s11191-020-00143-5

Roberts, D. A., & Bybee, R. W. (2014). Scientific literacy, science literacy, and science education. *Handbook of Research on Science Education*, 2:545-558.

Roth, W. M., & Barton, A. C. (2004). Rethinking scientific literacy. Psychology Press.

Russell, M. L., & Atwater, M. M. (2005). Traveling the road to success: A discourse on persistence throughout the science pipeline with African American students at a predominantly white institution. *Journal of Research in Science Teaching*, 42(6):691-715. DOI: https://doi.org/10.1002/tea.20068

Taylor, P. C., Fraser, B. J., & Fisher, D. L. (1997). Monitoring constructivist classroom learning environments. *International Journal of Educational Research*, 27:293-302. DOI:

https://doi.org/10.1016/S0883-0355(97)90011-2

Westbrook, J. H. (1960). Identifying Significant Research: Literature citation counting is evaluated as a means for identification of significant research. *Science*, 132(3435):1229-1234.

Xu, X., Chen, X., Jia, F., Brown, S., Gong, Y., & Xu, Y. (2018). Supply chain finance: A systematic literature review and bibliometric analysis. *International Journal of Production Economics*, 204:160-173. DOI: https://doi.org/10.1016/j.ijpe.2018.08.003

Van Eck, N. J., & Waltman, L. (2010). Software survey: VOSviewer, a computer program for bibliometric mapping. *Scientometrics*, 84(2):523-538. DOI: https://doi.org/10.1007/s11192-009-0146-3

Vogel, R., & Güttel, W. H. (2013). The dynamic capability view in strategic management: A bibliometric review. *International Journal of Management Reviews*, 15(4):426-446. DOI: https://doi.org/10.1111/ijmr.12000

Yager, R. E. (2000). A vision for what science education should be like for the first 25 years of a new millennium. *School Science and Mathematics*, 100(6):327-341. DOI: https://doi.org/10.1111/j.1949-8594.2000.tb17327.x

Zupic, I., & Čater, T. (2015). Bibliometric methods in management and organization. *Organizational Research Methods*, 18(3):429-447. DOI: https://doi.org/10.1177/1094428114562629.

Received: 20 December 2022
Revised: 24 January 2023
Accepted: 07 February 2023

ORIGINAL ARTICLE

Factors Affecting High School Students' Motivation and Career Interest in STEM Fields and Their Modeling

Esra Kızılay,[1] Havva Yamak[2]

1. *Erciyes University, 38280 Kayseri, Turkey*
2. *Gazi University, 06560 Ankara, Turkey*

***Abstract**: This study aims to investigate the motivation and career interest in STEM fields of high school students enrolled in public schools in the districts of Kayseri in Turkey according to various factors, to ascertain the relationship between the two variables, and to present a model for the relationship between the variables. The causal-comparative research and correlation (relational) research designs, which are among the quantitative research designs, were used in this study, which involved 1,667 students from five high education institutions situated. The research employed the Career Interest Scale in STEM Fields and the Motivation Scale in STEM Fields to gather data. It has been found that students whose favorite and most successful course is about STEM have much higher motivation and career interest in STEM fields than the other pupils. According to the study, students who are considering majoring in one of the university's STEM fields have much higher motivation and career interest in STEM fields than other students do in general. Additionally, the connection between motivation and career interest in STEM fields was looked at. According to research, students' motivation in STEM fields accounts for 70% of changes in their career interests in those fields.*

Science Insights Education Frontiers 2023; 16(1):2409-2433.
Doi: 10.15354/sief.23.or256

How to Cite: Kızılay, E., & Yamak, H. (2023). Factors affecting high school students' motivation and career interest in STEM fields and their modeling. Science Insights Education Frontiers, 16(1):2409-2433.

***Keywords:** STEM Career, STEM Motivation, Social Cognitive Career Theory, ARCS Theory*

***About the Author**: Esra Kızılay, Assist. Prof., PhD, Department of Science Education, Erciyes University, 38280 Kayseri, Turkey. E-mail: eguven@erciyes.edu.tr, ORCID: https://orcid.org/0000-0001-8329-0186*

Havva Yamak, Prof., PhD, Department of Science Education, Gazi University, 06560 Ankara, Turkey. E-mail: havva@gazi.edu.tr, ORCID: https://orcid.org/0000-0002-1666-0746

***Correspondence to**: Esra Kızılay at Erciyes University of Turkey.*

***Conflict of Interests**: None*

***Author Contribution**: This article was prepared as part of first author's doctoral thesis. The first author's contribution is more in the research. But all authors contributed to the study conception and design. All authors read and approved the final manuscript.*

***Availability of Data and Material:** The datasets are available from the first author on reasonable request.*

***Research Approval:** Research approval for the data collection was granted by the Ministry of National Education in Turkey.*

Introduction

WE are currently experiencing the Industry 4.0 transformation. Industry 4.0 makes it feasible to carry out a more effective and quicker production process while still producing goods of higher quality at lower costs. In this way, the nations' economies will evolve favorably over time, improving their competitiveness as well as their production efficiency. Because of this, catching Industry 4.0 is the most crucial requirement for a country to remain competitive and advance economically (BCG, 2019; Kuscu, 2018). Embracing Industry 4.0 requires keeping up with the times. The digital era, or Industry 4.0, is thought to have started in the twenty-first century. Technology has grown and advanced to astounding heights in our day and age. To succeed in the modern world, some talents have become crucial (Akgunduz, 2016; Beers, n.d.). They are referred to as 21st Century talents. Despite the fact that there are numerous categories for 21st century skills, it has become increasingly important to possess abilities like creativity and innovation, critical thinking and problem-solving, communication, cooperation, knowledge management, effective use of technology, career and life skills, and cultural awareness (Beers, n.d.). The talents that will be required the most in the future are also made public. The ability to solve complex problems, critical thinking and analysis, creativity, originality and initiative, leadership and social impact, technology use, monitoring and control, technology design and programming, flexibility, stress tolerance and flexibility, reasoning, problem-solving and reasoning, emotional intelligence, troubleshooting and user experience are the 15 skills that will be most in demand in 2025. Individuals in the workforce nowadays are also required to possess some talents in addition to these. The following are the top 10 abilities that employers are looking for in 2020: writing, strategy, python programming, mindfulness, meditation, gratitude, kindness, listening, algorithm, and grammar (World Economic Forum, 2020). People working nowadays are expected to possess these talents.

Today, it is impossible to handle real-world problems with knowledge based on a single subject due to the growing importance of Industry 4.0 technologies and an increase in knowledge. In order to solve a problem, one must therefore draw on knowledge from other fields and apply a variety of techniques. In order to combine information from other fields and to equip people with 21st century abilities, educational policies had to be revised. Education systems that prioritize interdisciplinary relationships over instruction centered around a single discipline have started to gain ground. STAEM (Science, Technology, Art, Engineering, and Mathematics) education provides the first instances of this (Yavuz, 2016). Today's educational strategy, known as STEM (Science, Technology, Engineering, and Mathematics) edu-

cation, offers an interdisciplinary integration of the disciplines of science, technology, engineering, and mathematics (Bybee, 2013).

STEM education gives people the skills they need to employ Industry 4.0 technology and prepares pupils for the future. In the end, it contributes to the nation's advancement in the field of competitiveness. With the goals and educational results of STEM education, all of these can be accomplished. For pupils, STEM education serves various functions. STEM literacy was broken down into 21st century skills, STEM employment preparedness, enthusiasm and participation, and the capacity to connect STEM disciplines. These are the goals of STEM education. The purposes of education and the results of that education are strongly tied to one another. As a result, the alignment of educational outcomes with objectives determines whether a program is successful. The outcomes of STEM education in this context include learning and success, 21st century abilities, selecting STEM courses, educational continuity and graduation rates, selecting a career in STEM, building a STEM identity, and the capacity to transfer knowledge across STEM fields (Honey et al., 2014). Studies on job interest, career motivation, and career choice, particularly in STEM sectors, have become more prevalent as a result of nations' desire to stand out in international competitiveness and the significance of STEM education.

Literature Review

Studies examining STEM interest and motivation in STEM disciplines can be found in the associated literature. When researches are analyzed, it becomes clear that interest and motivation are taken into account. As a result, it is impossible to draw a clear distinction between studies relating to STEM career interest and motivation. Robnett and Leaper (2012) looked into how gender, motivation, and friendship group traits affected high school students' interest in STEM careers. The study discovered that pupils' interest in STEM careers was predicted by group support and science passion. Christensen, Knezek, and Tyler-Wood (2015) looked at data indicating the STEM tendencies of high school students attending academies, as well as the causes of the stated interest in STEM. A high-quality motivational teacher, parental or family support, and student motivation are the elements determining kids' interest in STEM careers and fields. The aim of a study conducted by Bahar and Adiguzel (2016) was determined to examine the factors that affect the careers of American and Turkish high school students in STEM-related fields. According to the study, mother motivation for Turkish children and self-motivation for American students were the two most significant influences on STEM interest. Oliveros et al. (2016) evaluated the variables influencing students' decision to pursue STEM careers at three public universities in their study. Chittum, Jones, Akalin, and Schram (2017) looked at how an

after-school STEM program affected students' involvement and motivation. According to the study, it is crucial to focus on pupils' interests and motivations before the eighth grade if you want to maintain consistency in your STEM career aspirations. For the kids who were at this point in the research, Studio STEM was used. The application revealed that the Studio STEM participants' motivating attitudes about science and desire to graduate from college recovered faster than those of the non-participants. In a study by LaForce, Noble, and Blackwell (2017), the interests of high school students in problem-based learning and STEM jobs were investigated. The results of multivariate regression demonstrated that student performance in problem-based learning was related to both interest in pursuing a career in STEM and intrinsic passion for science. It was investigated whether programming experiences support better STEM enthusiasm among first-year female students in the study "Programming experience promotes higher STEM motivation among first-grade girls" conducted by Master, Cheryan, Moscatelli, and Meltzoff (2017). According to the study, girls who had expertise in programming displayed higher levels of self-efficacy and curiosity in technology than girls without such exposure. Rozek, Svoboda, Harackiewicz, Hulleman, and Hyde (2017) investigated how a parental motivational intervention affected kids' readiness for STEM coursework and interest in STEM careers. The study's findings demonstrated that a motivational intervention with parents had a significant impact on high school STEM readiness.

There are also some studies in the literature that include models based on the relationships between factors that affect STEM career interest and motivation. Generally; the relationships between variables such as self-efficacy, outcome expectation, environmental effects and STEM interest were modeled (Garriott et al., 2013; Bolds, 2017; Garriott et al., 2017; Turner et al., 2017; Sellami et al., 2017).

Importance and Purpose of the Research

The literature study revealed that there are several studies on high school students' careers in STEM disciplines, but there is a dearth of research with a large sample size that demonstrates the impact of various elements by combining the students' career interests and their motivation. It has been shown that there is a sizable vacuum in the pertinent literature, particularly for STEM areas, on motivation. Accordingly, it may be claimed that the study was an effort to fill a gap in the pertinent literature. The study is significant in this regard since it examines the relationships among numerous variables and presents a model for these variables, indicating the career interests and motivations of high school students in STEM areas.

Within the context of importance, the study's objectives are to identify the link between two variables, present a model for that relationship, and

investigate certain aspects that influence high school students' career interests and motivations in STEM disciplines.

Theoretical Framework

Social Cognitive Career Theory

The concept of career was used in the sense of professional development (Ozyurek, 2013). There are many career development theories, as can be seen by reviewing the literature on the subject. Some of them are the Occupational Chaos Theory, Social Cognitive Career Theory, Job Adaptation Theory, Personality Theory in Career Choice, and Cognitive Information Processing Approach (Niles & Harris-Bowlsbey, 2013). The notions suggested by the Social Cognitive Career Theory are not wholly original. But this theory applies the ideas of earlier theories to the world of work (Unsal, 2014). Lent, Brown, and Hackett provided an explanation of the Social Cognitive Career Theory in 1994. The three social cognitive systems that affect a person's professional development, according to the researchers, are self-efficacy beliefs, outcome expectations, and personal goals. The Social Cognitive Career Theory focuses on how these three systems and other elements, including a person's physical traits, environment, and behaviour, affect their career. In career development, the influences of personal traits like gender and ethnicity as well as contextual traits like career assistance were investigated. Lent et al. provided three models to explain how people develop their social cognitive careers on the basis of the mechanisms expressed as self-efficacy, result expectations, and personal goals. These have been grouped under the headings of interest model development, career choice model development, and performance model development (Lent et al., 1994).

Self-efficacy, result expectations, and interest are related to the model of interest development. The emergence of outcome expectations is a byproduct of self-efficacy. Contrarily, interest is a product of both self-efficacy and expectancy of the outcome. Additionally, experiences with learning have an indirect impact on interests (Lent et al., 1994). The areas that people are most interested in are those where they feel competent, which is to say, where their level of self-efficacy is high, and they anticipate the best results. In other words, people become disinterested in activities in which they define a low level of self-efficacy and their outcome expectations are negative (Unsal, 2014). High school students go through a process that is more suited for the development of the interest model of Social Cognitive Career Theory because this is the time when they are discovering their interests. This model was selected as the theoretical foundation in light of the research's potential professional applications.

ARCS Motivation Model

The concept of motivation was defined as incentive (Motivation, n.d.). The literature has a wide variety of motivational theories. They are split into two categories: content theories and process theories (Ulukus, 2016). Understanding the elements that motivate people to act is a key component of context theories of motivation. These theories are McClelland's accomplishment needs theory, Alderfer's V.I.G. theory, Herzberg's two-factor theory, and Maslow's hierarchy of needs theory (Sural Ozer & Topaloglu, 2008). Process theories are those that explain how people are motivated from the outside, for what reasons, and how they are motivated (Ulukus, 2016). These theories are expectancy value theory, equality theory, individual goals theory, behavior conditioning theory, and ARCS motivation theory (Kutu, 2011).

In 1984, Keller proposed the ARCS Motivation Model (Keller, 1984; cited in Keller, 2010). Four categories make up the ARCS Motivation Model: attention, relevance, confidence, and satisfaction (Keller, 2010). Given that it is a more recent theory and concentrates on both intrinsic and extrinsic drive, the ARCS motivation model was chosen as the normative framework for this investigation.

Method

Among the quantitative research designs used in this study were the causal-comparative research and correlation (relational) research designs. There are two aspects to the research. In the first section, many demographic factors were taken into consideration to analyze students' career goals and motivations for STEM areas. The causal-comparative research design, one of the quantitative research methods, was used to conduct this portion of the study. Investigating the causes that influence a phenomenon's outcomes is done through causal-comparative research (Sonmez & Alacapinar, 2011). For this reason, one or more categorical independent variables and one or more quantitative dependent variables are compared in causal-comparative research (Johnson & Christensen, 2014). Since demographic factors that influence students' career interests and motivations for STEM professions are evaluated in this section of the study, they are regarded as categorical independent variables. Students' motivations and career ambitions in STEM subjects were investigated as quantitative dependent variables. As a result, a causal-comparative research design was used to conduct this portion of the study.

The relationship between students' career interests and motivations for STEM areas, as well as the relationship between the sub-dimensions of these two variables, were looked at in the second phase of the study. One of the quantitative research types used in this study was the correlation research design. The link between one or more quantitative independent variables and

one or more quantitative dependent variables is explored in correlation research (Johnson & Christensen, 2014). This section of the study used a correlation research methodology to evaluate the relationship between students' motivation and their career interests in STEM disciplines.

Research Group

Since the motivation and interest in STEM careers will be examined in this study, a research group of students between the ages of 14 and 16 was chosen (Telman, 2006), which comprises children who have finished elementary school and are at the appropriate age to begin their career. Because people begin to identify their own interests and skills during their formative years in the 14–18 age range (Cakir, 2011). As a result, the demographic for the study was decided upon as being high school pupils in public schools of Kayseri's Kocasinan and Melikgazi districts in Türkiye. The study's sample was made up of 1667 high school students (573 boys and 1094 girls), who were chosen from this group using the proportionate stratified sampling method (Johnson & Christensen, 2014).

The formula proposed by Cochran (1962; cited in Balci, 2011) and frequently used in stratified sampling was used to determine the number of samples in the study. The calculation determined that 381 people would make up the sample size from a population of 47337 people in the research population, with a 1.96 confidence level and a 0.05 tolerance level. With a confidence level of 1.96 and a tolerance level of 0.05, it was decided that the study's sample size of 1667 participants was adequate. The proportions of the stratified variable in the universe are represented in the sampling in the same way using the proportional stratified sampling technique that was chosen for the research (Johnson & Christensen, 2014). "Institution type" was chosen as the stratification variable in this study. The stratification variables of the study are "Anatolian High School," "Anatolian Imam Hatip High School," and "Vocational and Technical Anatolian High School."

Data Collection Tools

Demographic Information Form, Career Interest Scale for STEM Fields (Kizilay et al., 2020) and Motivation Scale in STEM Fields (Kizilay et al., 2019) were used as data collection tools in the research. The Career Interest Scale in STEM Fields was developed for high school students. The scale comprises 20 items and is made up of three elements (interest, self-efficacy, and outcome expectancy), as well as mechanisms from the Social Cognitive Career Theory's interest development model. The total scale and its factors' Cronbach Alpha coefficient were shown to be higher than.90. According to Kizilay et al. (2020), the scale is a five-point Likert type. The 22-item Moti-

vation Scale in STEM Fields measures four ARCS Theory factors—attention, relevance, confidence, and satisfaction. The total scale and its factors' Cronbach Alpha coefficient were shown to be higher than.90. According to Kizilay et al. (2019), the scale is a five-point Likert type.

Analysis of Data

The calculated student scores were analyzed using the SPSS (Statistical Package for Social Sciences) 22.0 statistical package software and the AMOS (Analysis of Moment Structures) 24.0 package program.

It was first determined whether the data displayed a normal distribution during the analysis of the data gathered from the application. The examination of the data that was found to have a normal distribution used the independent groups t-test, one-way ANOVA, Pearson product-moment correlation coefficient, simple linear regression analysis, and path analysis. Also, the decision of whether students' answers are non-STEM fields was coded according to the STEM fields' classification of U.S. Bureau of Labor Statistics (URL-1) and Noonan (2017).

Results

The Impact of Gender on Career Interest in STEM Fields

The purpose of the independent groups' t-test was to determine whether there was a gender difference that was statistically significant in the career interests in STEM fields. The independent groups t-test was used to assess whether gender has a significant impact on career interest in STEM fields, and the results showed a significant difference between the mean scores of male and female students (Mean = 67.52 and Mean = 64.17, respectively). In favour of male students, this disparity was discovered (**Table 1**).

The Effect of Favorite Course on Career Interest in STEM Fields

A one-way ANOVA test was used to examine whether there was a significant difference in the career interests of the students participating in the study, according to their favourite courses. According to the test results, A significant difference was determined between the career interest averages of the students whose favourite course is STEM fields (Mean = 68.30), and

Table 1. T-test Results of Career Interest in STEM Fields in Terms of Gender.

Groups	N	Mean	S	sd	t	p
Male	573	67.52	11.62	1,665	5.727	0.000
Female	1,094	64.17	11.20			

Table 2. ANOVA Results of Career Interest for STEM Fields in Terms of Students' Favorite Courses.

Source of variance	Sum of squares	sd	Mean of squares	F	p	Significant difference
Between groups	13,434.125	2	6,717.062	54.482	0.000	1-3 2-3
Within groups	205,152.973	1,664	123.289			
Total	218,587.097	1,666				

1-No favorite course
2-Courses from non-STEM fields
3- Courses from STEM fields

Table 3. ANOVA Results of Career Interest in STEM Fields in Terms of Students' Most Successful Course.

Source of variance	Sum of squares	sd	Mean of squares	F	p	Significant difference
Between groups	9,675.778	2	4,837.889	38.534	0.000	1-3 2-3
Within groups	208,911.320	1,664	125.548			
Total	218,587.097	1,666				

1-No successful course
2-Courses from non-STEM fields
3- Courses from STEM fields

Table 4. ANOVA Results of Career Interest in STEM Fields in Terms of Students' Desired Major of the University.

Source of variance	Sum of squares	sd	Mean of squares	F	p	Significant difference
Between groups	12,122.378	3	4,040.793	32.547	0.000	1-4 2-4 3-4
Within groups	206,464.720	1,663	124.152			
Total	218,587.097	1,666				

1-There is no major in the university that he wants to choose
2-Undecided
3-Major from non-STEM fields
4-Major from STEM fields

the career interest averages of the students whose favourite course is non-STEM fields (Mean = 62.73), and career interest averages of the students whose do not like any course (Mean = 60.46). The results also showed that students who liked a STEM course the most had a higher career interest in STEM fields (**Table 2**).

The Effect of the Most Successful Course on Career Interest in STEM Fields

According to the courses in which they excelled, the research participants' career interest in STEM fields was compared using a one-way ANOVA test to see if there was a statistically significant difference. According to test results, students who were most successful in a STEM course had a score in career interest in STEM fields that averaged 68.16, whereas students who were most successful in a non-STEM course had a score career interest in STEM fields that averaged 63.29. Students who weren't successful in any course had much lower career interest in STEM fields point averages (Mean = 62.99) than those who did. The findings also indicated that pupils who excelled in a STEM course had a greater interest in a STEM-related career (**Table 3**).

The Effect of the Desired Major of the University on Career Interest in STEM Fields

The study's participants' career interests in STEM fields were compared to the departments they desired. They would major in a university a one-way ANOVA test to see if there was a statistically significant difference. The test findings showed a substantial difference between students who are considering selecting a department from a STEM majors at the university and the average points of other students in terms of their mean score of career interest in STEM fields. The findings indicated that students who are thinking about majoring in a STEM field have a greater interest in STEM careers (**Table 4**).

The Effect of Gender on Motivation in STEM Fields

The independent groups t-test was used to determine whether there was a statistically significant difference in motivation for STEM fields among the research participants based on gender. The independent groups t-test was used to establish whether gender has a significant impact on motivation towards STEM fields, and the results showed a significant difference between the mean scores of male and female students (Mean = 73.54 and Mean = 69.47, respectively) (**Table 5**).

Table 5. T-test Results of Students' Motivation in STEM Fields by Gender.

Groups	N	Mean	S	sd	t	p
Male	573	73.54	13.42	1,665	5.920	0.000
Female	1,094	69.47	13.30			

Table 6. ANOVA Results of Motivation in STEM Fields in Terms of Students' Favorite Courses.

Source of variance	Sum of squares	sd	Mean of squares	F	p	Significant difference
Between groups	17,988.798	2	8,994.399	52.607	0.000	1-3 2-3
Within groups	284,498.572	1,664	170.973			
Total	302,487.369	1,666				

1-No favorite course
2-Courses from non-STEM fields
3- Courses from STEM fields

Table 7. ANOVA Results of Motivation in STEM Fields in Terms of Students' Most Successful Course.

Source of variance	Sum of squares	sd	Mean of squares	F	p	Significant difference
Between groups	15,741.756	2	7,870.878	45.675	0.000	1-3 2-3
Within groups	286,745.613	1,664	172.323			
Total	302,487.369	1,666				

1-No successful course
2-Courses from non-STEM fields
3- Courses from STEM fields

Table 8. ANOVA Results of Motivation in STEM Fields in Terms of Students' Desired Major of the University.

Source of variance	Sum of squares	sd	Mean of squares	F	p	Significant difference
Between groups	20,946.830	3	6,982.277	41.243	0.000	1-4 3-4
Within groups	281,540.539	1,663	169.297			
Total	302,487.369	1,666				

1-There is no major in the university that he wants to choose
2-Undecided
3-Major from non-STEM fields
4-Major from STEM fields

The Effect of Favorite Course on Motivation in STEM Fields

To determine whether there was a significant difference between the students who participated in the STEM research and their favourite courses, a one-way ANOVA test was utilized. A significant difference was found between the motivation point averages for STEM fields of students who enjoy a STEM lesson the most (Mean = 74.30), the motivation point averages for STEM fields of students who adore a non-STEM lesson the most (Mean = 67.91), and the motivation point averages for STEM fields of students who do not enjoy any of the lessons (Mean = 64.37). The findings also indicated that students were more inspired to pursue STEM fields when they enjoyed a STEM-related lesson the most (**Table 6**).

The Effect of the Most Successful Course on Motivation in STEM Fields

According to the courses in which they excelled; a one-way ANOVA test was conducted to determine whether there was a statistically significant difference in the motivation of the students for motivation in STEM fields. A significant difference was found between the motivation point averages for STEM fields of students who performed best in a STEM course (Mean = 74.49), and those of the students who performed best in a non-STEM course (Mean = 68.29). The findings also indicated that students who did well in a STEM course had greater motivation in STEM fields (**Table 7**).

The Effect of the Desired Major of the University on Motivation in STEM Fields

According to the university departments, they believed they would choose; a one-way ANOVA test was conducted to see whether there was a statistically significant difference in the motivation of the students participating in the research about the STEM fields. The average points of the other students and the students who are considering picking a STEM majors at the university had a substantial difference in their motivation scores for the STEM fields (Mean = 74.73), according to the test findings. The findings also indicated that kids who are thinking about majoring in a STEM degree in university are more motivated to pursue STEM fields (**Table 8**).

Table 9. The Relationship between the Sub-Dimensions of Career Interest in STEM Fields.

	Self-Efficacy	Outcome Expectation	Interest
Self-Efficacy	1.00		
Outcome Expectation	0.514	1.00	
Interest	0.659	0.669	1.00

Table 10. The Relationship between the Sub-Dimensions of Motivation in STEM Fields.

	Attention	Relevance	Confidence	Satisfaction
Attention	1.00			
Relevance	0.652	1.00		
Confidence	0.730	0.751	1.00	
Satisfaction	0.681	0.586	0.695	1.00

Table 11. Regression Findings on Motivation and Career Interest in STEM Fields.

Variable	B	Standard error	B	t	p
Constant	14.959	0.825	-	18.141	0.000
Motivation	0.711	0.011	0.836	62.170	0.000

R=0.836
R^2=0.699
$F_{(1-1665)}$=3,865.133
p=0.000

Findings Regarding the Sub-Dimensions of Career Interest in STEM Fields

To determine whether there is a correlation between high school students' career interest sub-dimensions for STEM fields, the Pearson product-moment correlation coefficient was determined. According to Sencan (2005), a correlation coefficient between 0.40 and 0.59 denotes a moderate associa-

tion, 0.60 to 0.80 denotes a strong relationship, and a number higher than 0.80 denotes a very strong relationship. **Table 9** displays the findings of the correlation between the career interest sub-dimensions for STEM fields. When **Table 9** is examined, it can be seen that there is a strong correlation between interest and outcome expectation, a strong correlation between interest and self-efficacy, and a moderate correlation between outcome expectation and self-efficacy.

Findings Regarding the Sub-Dimensions of Motivation in STEM Fields

To determine whether there is a correlation between high school students' motivation sub-dimensions for STEM fields, the Pearson product-moment correlation coefficient was determined. According to Sencan (2005), a correlation coefficient between 0.40 and 0.59 denotes a moderate association, 0.60 to 0.80 denotes a strong relationship, and a number higher than 0.80 denotes a very strong relationship. **Table 10** displays the findings of the correlation between the motivation sub-dimensions for STEM fields. There is a strong correlation between relevance and attention, confidence and attention, satisfaction and attention, confidence and relevance, and satisfaction and confidence, according to **Table 10**. Additionally, a moderate correlation between satisfaction and the relevance sub-dimensions was discovered.

Findings Related to the Relationship between Career Interest and Motivation for STEM Fields

In the study, the Pearson correlation coefficient was calculated to examine whether there is a relationship between high school students' career interests in STEM fields and their motivation towards STEM fields. The correlation coefficient in the study was found to be 0.836. This value showed that there was a high correlation between the variables.

Regression Findings on Motivation and Career Interest in STEM Fields

To assess whether motivation for STEM fields was a significant predictor of students' career interests in STEM fields, basic linear regression analysis was used in the study (**Table 11**).

A substantial association between motivation towards STEM fields and career interest was found as a result of the basic linear regression analysis carried out to ascertain how much the motivation towards STEM fields

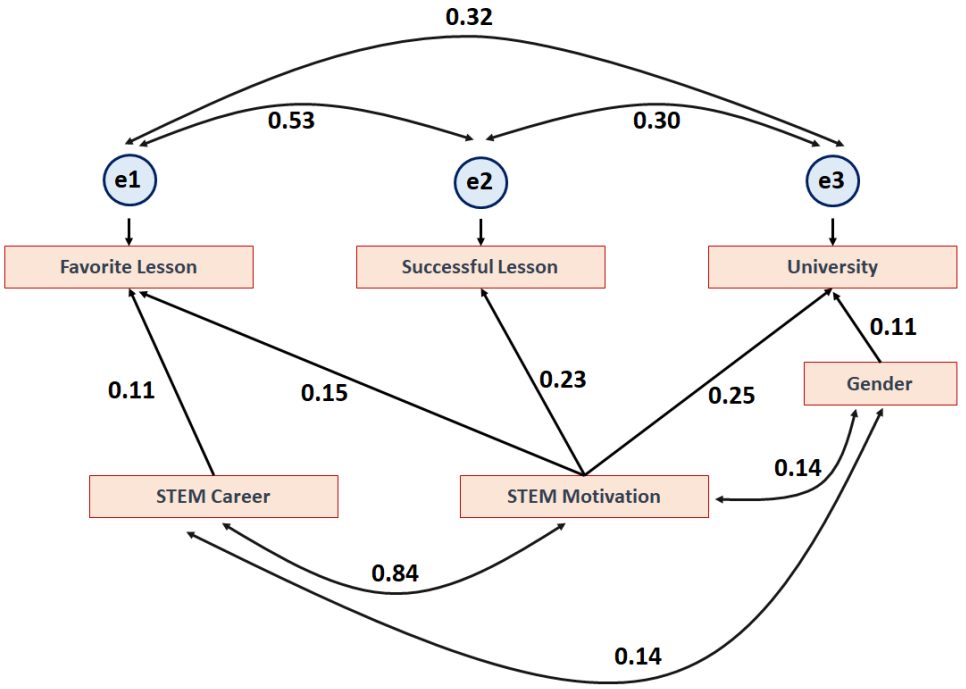

Figure 1. Path Diagram.

predicted the career interests of students towards STEM fields. It has been discovered that motivation for STEM fields is a highly important predictor of career interest in STEM fields. When the R2 value was looked at, it was discovered that motivation for STEM fields might account for 70% of the change in students' career interest in those fields. The motivation significance test confirmed that motivation was a significant predictor. The regression equation is provided below in accordance with the findings of the analysis of regression.

$$\textit{Career interest in STEM fields} = (0.711 \times \textit{Motivation in STEM fields}) + 14.959$$

Modeling Career Interest and Motivation in STEM Fields

Path analysis was used in the study to assess the strength and importance of some of the correlations between the variables (Meydan & Sesen, 2015). It was decided which model will be tested in the path analysis after looking at prior analyses and relevant literature. As a result, **Figure 1** contains the pro-

Table 12. Total and Direct Effect Values.

Variables	Gender	Career Interest in STEM Fields	Motivation in STEM Fields
The department they considered choosing at the university	0.115	0.000	0.245
Most successful course	0.000	0.000	0.228
Favorite course	0.000	0.109	0.150

posed test model's path diagram. Here, the analysis was conducted after converting the students' gender, favourite course, most successful course, and departmental preference into two-category representative variables. Because categorical variables must be two-category variables in regression analyses in order to determine the correlation (Can, 2014).

The study's model's coefficients of fit were discovered to be consistent with the established limit values. The model's χ^2 / sd value was determined to be 1.799. The maximum value for χ^2 / sd that is permitted is 5. According to Ozdamar (2016), a number greater than 5 denotes mismatch. The CFI score was determined to be 0.999. According to Ozdamar (2016), a CFI value of more than 0.90 is acceptable.

According to the model, there is a connection between students' favourite STEM courses and their interest in careers in such disciplines. The students' favourite course, the most successful course, and the department they considered choosing at the university were a good association between the students' motivation for these fields. The students' preference for STEM-related fields at the university and the fact that they were male were found to be positively correlated. In addition, there are correlations between career interest in STEM disciplines and male gender as well as between motivation for STEM fields and being male. It has been found that there are favourable links between the most well-liked and successful course and the university department, which is one of the STEM fields. These associations, or pathways, were all statistically significant ($p < 0.05$). It was found that there were no indirect impacts between the variables when the findings were examined. The standardized total and direct effect values were found to be identical. **Table 12** provides the total and direct effect values between the variables.

According to **Table 12**, being male predicts choosing a STEM major at university. Career interest in STEM fields predicts that the most popular subject will be STEM fields. Motivation for STEM fields predicts choosing a department from STEM fields at university, the most successful course being one of the STEM fields, and the most popular class being one of the STEM fields. In addition, gender predicts career interest in STEM fields and motivation towards STEM fields.

Conclusion and Discussion

The study examined high school students' career interest and motivation in STEM fields in terms of many independent variables. The investigation done to establish if gender has a significant impact on high school students' interest in STEM careers produced results that showed that male students' interest was much higher than that of female students. The study found that male pupils were much more motivated than female students to pursue STEM fields. Gender perception can be described as a potential explanation for why female students' scores are much lower than male students in terms of the effect of gender on career interest and motivation towards STEM fields. Occupations outside of STEM fields are thought to be particularly suitable for female students. According to Gunindi Ersoz (2016), careers like teaching and nursing are thought to be particularly suitable, where female students would have time to care for their homes and children, are appropriate choices for them. The orientation of female students toward STEM disciplines is impacted by this circumstance. Results from a study with university students also showed that gender perception is a factor. According to the report, 27% of college students cited "appropriate for my gender" as a factor in their decision to study in a particular field. Gender compatibility was the primary factor, particularly for girl students, in selecting a department (Korkut-Owen et al., 2012).

Some studies produced outcomes that were comparable to those of this investigation when the pertinent literature was reviewed. Similar outcomes were observed in Zor's study (2006). According to the study, male pupils were more interested than female students in careers in science, mathematics, electricity, electronics, and computers. The study that involved high school students came to conclusions that were somewhat similar to those of the current study. According to Yelken's (2008) study, engineering is the field that male students believe they would most enjoy working in, while female students believe they would most enjoy teaching. Similar findings were made on university students by Dabney et al. (2012). In the study, there were four and a half times as many male university students who expressed interest in STEM careers as there were female students. Male high school students are more interested in STEM jobs than female pupils, according to a study by Robnett and Leaper (2012). Additionally, it was discovered that gender was a predictor of interest in STEM careers. The findings of a study done on high school pupils likewise came up with similar conclusions. Regarding how gender affects students' career aspirations, it has been shown that male students typically demonstrate a greater interest in engineering-related disciplines (Sadler et al., 2012). Boys were found to be much more interested in one of the STEM fields than girls were in another study with high school students (Lichtenberger & George-Jackson, 2013).

Similar findings were found in a study by Altay Kose and Yangin (2015) that looked at the interests of primary and secondary school pupils in scientific careers. In the study, it was found that male students were typically interested in careers in engineering and computers, whereas female students were typically interested in careers in medicine and psychology. According to a report by Welch et al. (2015), among middle school pupils, girls' interest in STEM was lower than boys' interest. In a study they did, Shin et al. (2017) found that male students had much stronger motivation for a future in science. According to Bolds' study (2017), the majority of high school pupils who selected to major in STEM fields at universities were men. Among middle school children, boys are generally more willing to pursue a career in STEM and exhibit more interest in STEM fields, according to a study by Christensen and Knezek (2017). Parallel to this study, Sahin et al. (2017) found that the 9th grade students' choice of STEM branches was influenced by their gender. According to the report, male pupils were more inclined to think about majoring in STEM fields at college. The gender of students in the 10th and 12th grades and their self-efficacy, anticipation of outcomes, and interest in STEM fields were also found to be significantly correlated by Turner et al. (2017). Male secondary school students showed greater interest in STEM jobs than female students, according to Alsup's (2015) study, however this difference was not statistically significant. Studies that reached different conclusions from this one are also included in the literature. A different outcome from this study was discovered in a survey of high school students, and it was shown that female students exhibited a considerably higher interest in STEM careers (Christensen et al., 2014). In contrast, Brown et al. (2016) found no appreciable differences in the STEM interests of male and female pupils in a study they did with sixth graders. In a study they did, Yerdelen et al. (2016) also demonstrated that secondary school pupils, both boys and girls, do not differ from one another in terms of their interest in any of the STEM professions.

According to the study, the students who enjoyed and excelled in STEM courses the most had a much higher level of career interest and motivation in STEM fields than the other students. According to the report, students who are thinking about majoring in one of the university's STEM subjects tend to have much higher career interests and motivations than other students. However, it was shown that there was a moderate impact of the department they chose on the students' interests and inclinations. It has been found that the department intend to major in at university of students can account for a small portion of the variation in career interest and motivation in STEM fields. In the study, Sahin et al. (2017) observed a comparable outcome. According to the study, there was a strong correlation between high school interests and future employment inclinations. Sari et al. (2018)'s arti-

cle revealed that the students' attitudes towards STEM disciplines, STEM career interests in STEM-related occupations significantly increased.

The study looked at the relationship between the sub-dimensions of career interest in STEM fields. In a different study with high school students, Garriott et al. (2017) discovered a favorable, substantial, and strong correlation between students' self-efficacy in math and science and their interest in those subjects. Similar to the research, Halim et al. (2018) discovered a favorable and substantial association between students' STEM self-efficacy and STEM job preferences. Another study, including high school students, found a direct correlation between interest in STEM careers and intrinsic coding interest, coding self-efficacy, and coders' perceptions (Jiang et al., 2022).

The study looked at the connection between the sub-dimensions of motivation in STEM fields. The sub-dimensions of relevance and attention, confidence and attention, satisfaction and attention, confidence and relevance, and satisfaction and confidence have all been found to be strongly correlated with one another. Additionally, a moderate correlation between satisfaction and the relevance sub-dimensions was discovered.

According to the study, there is a strong link between motivation and career interest in STEM fields. The study found a substantial correlation between career interest and motivation toward STEM fields. Motivation in STEM fields has been found to be an important predictor of career interest in STEM fields. In a study, it was discovered that high school graduates' motivating traits were significantly and favorably associated with their entry into STEM fields (Wang, 2013). Another study found that high school pupils' own motivation to pursue STEM subjects had the primary influence on their interests (Christensen et al., 2015). Another study that looked at the elements influencing high school students' interest in STEM career found that American students' intrinsic motivation was the most significant component (Bahar & Adiguzel, 2016). Evidence was found that fostering students' motivation has a positive impact on their willingness to choose a STEM field of study in a study whose main goal was to analyze the impact of the motivational design of mathematics, physics, and chemistry courses in high schools (Aeschlimann et al., 2016).

According to the study, motivation in STEM fields accounts for 70% of high school pupils' career interests towards those fields. According to the research's path analysis, several correlations between variables like gender, preferred and successful courses, motivation in STEM fields, and career interest were modeled. In a study conducted in the related literature, it was explored how several factors, including instructor influence and students' self-confidence, predict their interest in STEM (Sellami et al., 2017). The impacts of self-efficacy, result expectations, and parental support variables on interest in mathematics and science were modeled by Garriott et al. (2013).

Multiple model analyses were carried out by Aeschlimann et al. (2016) in a study looking at factors including STEM job choice, interest, and motivation for high school students. In the study by Bolds (2017), the connections between many variables, including self-efficacy in math and science, outcome expectations, curiosity, environmental support, and hurdles, were examined. According to Garriott et al. (2017), the path diagram contained elements including self-efficacy, interest, and goals. It was shown that self-efficacy significantly predicted interest. Similar to this study, Turner et al. (2017) modeled some factors. Relationships between variables like gender, parental support, career desire, STEM aptitude, and result expectations were modeled in the study. Gender substantially impacted efficacy, outcome expectation, and interest, according to the model.

Limitations and Future Directions

According to the study, male students showed much greater career interest in STEM fields than did female pupils. Activities for girls can be conducted at school and in classrooms to pique their interest. To pique the interest of female students in STEM fields, vocational tours might be planned in areas like engineering. It can be having looked at potential explanations for why female students' interest in STEM careers is lower than that of male students.

According to the study, male students were much more motivated to pursue STEM fields than female students. Activities for girls can be held at school and in classrooms to boost female students' motivation. In order to lessen the impact of the gender factor, it is possible to ensure that female students meet or visit women working in STEM fields, given the factors affecting students' motivation. It can be having looked at potential explanations for why female students' interest in STEM disciplines is lower than that of male students.

It was investigated how the sub-dimensions of career interest in STEM fields related to one another. The study looked at how the Motivation Scale in STEM Fields' sub-dimensions related to one another. It is possible to look at how each sub-dimension interacts with other variables.

The quantitative study of high school students' career interests and motivations for STEM fields is one of the limitations of this study. With the help of qualitative research to be conducted, high school students' career interests and motivations towards STEM fields can be revealed in all aspects.

The fact that the sample consisted of high school students in Kayseri, Turkey, is another limitation of this study. By carrying out a comparable study with students in other cities, it will be possible to draw more general conclusions about high school students in Turkey.

Other research may focus on examining various factors that influence kids' interest in STEM careers. By looking at students' motivation and ca-

reer interest in STEM fields with various variables, several path diagrams may be produced.

References

Aeschlimann, B., Herzog, W., & Makarova, E. (2016). How to foster students' motivation in mathematics and science classes and promote students' STEM career choice. A study in Swiss high schools. *International Journal of Educational Research*, 79:31-41. DOI: https://doi.org/10.1016/j.ijer.2016.06.004

Akgündüz, D. (2016). Yeni nesil okulda teknoloji entegrasyonu. M. Yavuz (Ed.), in Yeni Nesil Okul "Araştıran Okul" (s. 133-185). Eğitim Yayınevi.

Alsup, P. R. (2015). The effect of video interviews with STEM professionals on STEM-subject attitude and STEM-career interest of middle school students in conservative Protestant Christian schools. PhD Thesis, Liberty University, Amerika.

Altay Kose, T., & Yangin, S. (2015). İlkokul ve ortaokul öğrencilerinin bilimsel kariyer ilgileri. *Recep Tayyip Erdoğan Üniversitesi Sosyal Bilimler Dergisi*, 1(1).

Bahar, A., & Adiguzel, T. (2016). Analysis of factors influencing ınterest in STEM career: Comparison between American and Turkish high school students with high ability. *Journal of STEM Education: Innovations and Research*, 17(3):64-69.

Balci, A. (2011). Sosyal bilimlerde araştırma: Yöntem, teknik ve ilkeler. Pegem Akademi.

BCG (2019). Available at: https://www.bcg.com/capabilities/operations/embracing-industry-4.0-rediscovering-growth.aspx

Beers, S. Z. (n.d.). 21st Century Skills: Preparing Students for THEIR Future.

Bolds, T. (2017). A structural and ınterseccional analysis of high school students' STEM career development using a social cognitive career theory framework. PhD Thesis, Syracuse University, Amerika.

Brown, P. L., Concannon, J. P., Marx, D., Donaldson, C. W., & Black, A. (2016). An examination of middle school students' STEM self-efficacy with relation to interest and perceptions of STEM. *Journal of STEM Education: Innovations and Research*, 17(3):27.

Bybee, R. W. (2013). The case for STEM education: Challenges and opportunities. Arlington, Virginia: NSTA Press.

Cakir, M. A. (2011). Meslek seçimi, mesleki karar ve mesleki kararsızlık. Anı Yayıncılık.

Can, A. (2014). SPSS ile bilimsel araştırma sürecinde nicel veri analizi (2. Baskı). Pegem Akademi.

Chittum, J. R., Jones, B. D., Akalin, S., & Schram, Á. B. (2017). The effects of an afterschool STEM program on students' motivation and engagement. *International Journal of STEM Education*, 4(1):11. DOI: https://doi.org/10.1186/s40594-017-0065-4

Christensen, R., & Knezek, G. (2017). Relationship of middle school student STEM interest to career intent. *Journal of Education in Science, Environment and Health*, 3(1):1-13. DOI: https://doi.org/10.21891/jeseh.275649

Christensen, R., Knezek, G., & Tyler-Wood, T. (2014). Student perceptions of Science, Technology, Engineering and Mathematics (STEM) content and careers. *Computers in Human Behavior*, 34:173-186. DOI: https://doi.org/10.1016/j.chb.2014.01.046

Christensen, R., Knezek, G., & Tyler-Wood, T. (2015). A retrospective analysis of STEM career interest among mathematics and science academy students. *International Journal of Learning, Teaching and Educational Research*, 10(1).

Dabney, K. P., Tai, R. H., Almarode, J. T., Miller-Friedmann, J. L., Sonnert, G., Sadler, P. M., & Hazari, Z. (2012). Out-of-school time science activities and their association with career interest in STEM. *Inter-*

national Journal of Science Education, Part B, 2(1):63-79. DOI: https://doi.org/10.1080/21548455.2011.629455

Garriott, P. O., Flores, L. Y., Prabhakar, B., Mazzotta, E. C., Liskov, A. C., & Shapiro, J. E. (2013). Parental support and underrepresented students' math/science interests: The mediating role of learning experiences. *Journal of Career Assessment*, 22(4):627-641. DOI: https://doi.org/10.1177/1069072713514933

Garriott, P. O., Hultgren, K. M., & Frazier, J. (2017). STEM stereotypes and high school students' math/science career goals. *Journal of Career Assessment*, 25(4):585-600. DOI: https://doi.org/10.1177/1069072716665825

Gunindi Ersoz, A. (2016). Toplumsal cinsiyet sosyolojisi. Anı Yayıncılık.

Halim, L., Rahman, N. A., Ramli, N. A. M., & Mohtar, L. E. (2018). Influence of students' STEM self-efficacy on STEM and physics career choice. AIP Conference Proceedings içinde. AIP Publishing.

Honey, M., Pearson, G., & Schweingruber, H. (Eds.) (2014). STEM integration in K-12 education: Status, prospects, and an agenda for research. Washington, D.C.:The National Academies Press.

Jiang, H., Chugh, R., Turnbull, D., Wang, X., & Chen, S. (2022). Modeling the impact of intrinsic coding interest on STEM career interest: evidence from senior high school students in two large Chinese cities. *Education and Information Technologies*, 1-21.

Johnson, B., & Christensen, L. (2014)., Eğitim Araştırmaları: Nicel, Nitel ve Karma Yaklaşımlar (S. B. Demir (Çev. Ed.)). Eğiten Kitap.

Keller, J. M. (2010). Motivational design for learning and performance: The ARCS model approach. New York, USA: Springer.

Kizilay, E., Yamak, H., & Kavak, N. (2019). Motivation scale for STEM fields. *Journal of Computer and Education Research*, 7(14):540-557. DOI: https://doi.org/10.18009/jcer.617514

Kizilay, E., Yamak, H., & Kavak, N. (2020). Development of the STEM career ınterest scale for high school students. *European Journal of Educational Sciences*, 7(3):48-70. DOI: https://doi.org/10.19044/ejes.v7no3a4

Korkut-Owen, F., Kepir, D. D., Ozdemir, S., Ozlem, U., & Yilmaz, O. (2012). Üniversite öğrencilerinin bölüm seçme nedenleri. Mersin Üniversitesi Eğitim Fakültesi Dergisi, 8(3).

Kuscu, P. C. (2018). Yeni bir dönem: "Sanayi 4.0". İŞKUR Meslek Seçimine Destek, 5. Ankara.

Kutu, H. (2011). Yaşam temelli ARCS öğretim modeliyle 9. sınıf kimya dersi "hayatımızda kimya" ünitesinin öğretimi. Doktora Tezi, Atatürk Üniversitesi Eğitim Bilimleri Enstitüsü, Erzurum.

LaForce, M., Noble, E., & Blackwell, C. (2017). Problem-based learning (PBL) and student interest in STEM careers: The roles of motivation and ability beliefs. *Education Sciences*, 7(4):92. DOI: https://doi.org/10.3390/educsci7040092

Lent, R. W., Brown, S. D., & Hackett, G. (1994). Toward a unifying social cognitive theory of career and academic interest, choice, and performance. *Journal of Vocational Behavior*, 45:79-122.

Lichtenberger, E., & George-Jackson, C. (2013). Predicting high school students' interest in majoring in a STEM field: Insight into high school students' postsecondary plans. *Journal of Career and Technical Education*, 28(1). DOI: https://doi.org/10.21061/jcte.v28i1.571

Master, A., Cheryan, S., Moscatelli, A., & Meltzoff, A. N. (2017). Programming experience promotes higher STEM motivation among first-grade girls. *Journal of Experimental Child Psychology*, 160, 92-106.

Meydan, C. H., & Sesen, H. (2015). Yapısal eşitlik modellemesi: AMOS uygulamaları (2. Baskı). Ankara: Detay Yayıncılık.

Motivation (n.d.). Türk Dil Kurumu içinde. Available at: http://tdk.gov.tr/index.php?option=com_karsilik&arama=kelime&guid=TDK.GTS.59fc60eba080b5.26227847sayfasındanerişilmiştir

Niles, S. G., & Harris-Bowlsbey, J. (2013). 21. Yüzyılda Kariyer Gelişimi Müdahaleleri (4. Basımdan Çeviri), (F. Korkut Owen (Çev. Ed.)). Nobel.

Noonan, R. (2017). Office of the Chief Economist, Economics and Statistics Administration, U.S. Department of Commerce. (March 30, 2017). STEM jobs: 2017 update (ESA Issue Brief # 02-17). Available at: http://www.esa.gov/reports/stem-jobs-

2017-updatesayfasındanerişilmiştir

Oliveros, M. A., Vargas, L. E., Valdez, B., Cabrera, E., Schoor, M., & Arcos, J. L. (2016). Student motivation in STEM careers at three northwest universities of Mexico. *Creative Education*, 7(18):2829. DOI: https://doi.org/10.4236/ce.2016.718262

Ozdamar, K. (2016). Eğitim, sağlık ve davranış bilimlerinde ölçek ve test geliştirme/ yapısal eşitlik modellemesi. Nisan Kitabevi.

Ozyurek, R. (2013). Kariyer psikolojik danışmanlığı kuramları: Çocuk ve ergenler için kariyer rehberliği uygulamaları. Ankara: Nobel.

Robnett, R. D., & Leaper, C. (2012). Friendship groups, personal motivation, and gender in relation to high school students' STEM career interest. *Journal of Research on Adolescence*, 23(4):652-664.

Rozek, C. S., Svoboda, R. C., Harackiewicz, J. M., Hulleman, C. S., & Hyde, J. S. (2017). Utility-value intervention with parents increases students' STEM preparation and career pursuit. *Proceedings of the National Academy of Sciences*, 114(5):909-914. DOI: https://doi.org/10.1073/pnas.1607386114

Sadler, P. M., Sonnert, G., Hazari, Z., & Tai, R. (2012). Stability and volatility of STEM career interest in high school: A gender study. *Science Education*, 96(3):411-427. DOI: https://doi.org/10.1002/sce.21007

Sahin, A., Ekmekci, A., & Waxman, H. C. (2017). Collective effects of individual, behavioral, and contextual factors on high school students' future STEM career plans. *International Journal of Science and Mathematics Education*, 1-21. DOI: https://doi.org/10.1007/s10763-017-9847-x

Sari, U., Alici, M., & Sen, O. F. (2018). The effect of STEM instruction on attitude, career perception and career interest in a problem-based learning environment and student opinions. *The Electronic Journal for Research in Science & Mathematics Education*, 22(1).

Sellami, A., El-Kassem, R. C., Al-Qassass, H. B., & Al-Rakeb, N. A. (2017). A Path Analysis of Student Interest in STEM, with Specific Reference to Qatari Students. *EURASIA Journal of Mathematics Science and Technology Education*, 13(9):6045-6067. DOI: https://doi.org/10.12973/eurasia.2017.00999a

Sencan, H. (2005). Sosyal ve davranışsal ölçümlerde güvenilirlik ve geçerlilik. Seçkin Yayıncılık.

Shin, S., Lee, J. K., & Ha, M. (2017). Influence of career motivation on science learning in Korean high-school students. *EURASIA Journal of Mathematics Science and Technology Education*, 13(5):1517-1538. DOI: https://doi.org/10.12973/eurasia.2017.00683a

Sonmez, V., & Alacapinar, F. G. (2011). Örneklendirilmiş bilimsel araştırma yöntemleri. Ankara: Anı Yayıncılık.

Sural Ozer, P., & Topaloglu, T. (2008). Motivasyonda kapsam kuramları. C. Serinkan (Ed.), Liderlik ve Motivasyon içinde. Ankara: Nobel Yayın Dağıtım. Available at: http://www.tayfuntopaloglu.com/pdf/tayfun_topaloglu_motivasyonda_kapsam_kuramlari.pdf

Telman, C. (2006). Başarıya giden yolda meslek seçimi. Epsilon.

Turner, S. L., Joeng, J. R., Sims, M. D., Dade, S. N., & Reid, M. F. (2017). SES, gender, and STEM career interests, goals, and actions: A test of SCCT. *Journal of Career Assessment*, 27(1):134-150. DOI: https://doi.org/10.1177/1069072717748665

Ulukus, K. S. (2016). Motivasyon teorileri ve lider yöneticilik unsurlarının bireylerin motivasyonuna etkisi. *Akademik Sosyal Araştırmalar Dergisi*, 4(25):247-262.

Unsal, P. (2014). Kariyer gelişim kuramları ve kariyer danışmanlığı. Nobel.

URL-1. STEM occupations list. Available at: https://www.bls.gov/oes/stem_list.xlsx

Welch, C., Dunbar, S., & Rickels, H. (2015). STEM Report: STEM Interest and Achievement on the Iowa Assessments. Iowa Testing Programs, University of Iowa.

World Economic Forum (2020). The Future of Jobs Report 2020. Available at: https://www3.weforum.org/docs/WEF_Future_of_Jobs_2020.pdf?_gl=1*1g88ujj*_up*MQ..&gclid=CjwKCAjw79iaBhAJEiwAPYwoCN10mC6hWo3idCmLNu-C-qoRGTsOzqWFbKIrxVXsSsm75qqLlTUhrhoCxC8QAvD_BwE

Yavuz, M. (2016). "Yeni nesil okul"un kavramsal inşası. M. Yavuz (Ed.), Yeni Nesil Okul "Araştıran Okul" içinde (s. 3-11). Konya: Eğitim Yayınevi.

Yelken, K. (2008). Orta öğretim son sınıf öğrencilerinin üniversite tercihlerini ve meslek seçimini etkileyen faktörler: Sakarya il merkezi örneği. Yayınlanmamış Yüksek Lisans Tezi, Sakarya Üniversitesi Sosyal Bilimler Enstitüsü, Sakarya.

Yerdelen, S., Kahraman, N., & Tas, Y. (2016). Low socioeconomic status students' STEM career interest in relation to gender, grade level, and STEM attitude. Journal of Turkish Science Education, 13:59-74.

Zor, H. (2006). Konya ili ortaöğretim okulları öğrencilerinin alan ve meslek seçimlerinin bölgelere göre değerlendirilmesinin çok değişkenli istatiksel analizi. Yüksek Lisans Tezi, Selçuk Üniversitesi Fen Bilimleri Enstitüsü, Konya.

Received: 20 December 2022
Revised: 26 January 2023
Accepted: 21 February 2023

ORIGINAL ARTICLE

Contextual Scaffolding in Secondary Geography Education: A Lesson Study of the Instruction of "The Middle East"

Chunxia Lu

Wuxi Taying Middle School, Wuxi 214011, Jiangsu, China

***Abstract**: The utilization of instructional scaffolding is a crucial element in the process of imparting novel knowledge or skills to students. This approach involves the teacher providing and modifying support for students in order to optimize their classroom participation and academic outcomes. The present study offers an examination of a seventh-grade geography lesson focused on the Middle East. The lesson employs contextual scaffolding, supported by visual aids, throughout various teaching processes such as lesson introduction, classroom inquiry, review, and summary.*

Science Insights Education Frontiers 2023; 16(1):2435-2444.
Doi: 10.15354/sief.23.or261

How to Cite: Lu, C. (2023). Contextual scaffolding in secondary geography education: A lesson study of the instruction of "The Middle East". Science Insights Education Frontiers, 16(1):2435-2444.

***Keywords:** Instructional Scaffolding, Contextual Scaffolding, Visual Aids, Secondary Geography Education*

***About the author:** Chunxia Lu, Wuxi Taying Middle School, Wuxi 214011, Jiangsu, China. E-mail: 867237182@qq.com*

***Correspondence to**: Chunxia Lu in Wuxi Taying Middle School of China.*

***Conflict of Interests**: None*

JEROME Bruner, an American psychologist, introduced the term "scaffolding" in the field of education during the 1970s. The pedagogical strategy of instructional scaffolding is founded on Vygotsky's zone of proximal development theory. This approach involves the teacher breaking down lessons into manageable segments and progressively withdrawing support as students demonstrate greater proficiency in comprehending and applying new concepts and information. As per the scaffolding theory, it is necessary for students to receive guidance and aid from teachers or other proficient individuals when they commence the process of acquiring a novel concept. However, it is imperative that such assistance be provided on a temporary basis and be adaptable. As the learning process advances, students' reliance on the teacher is expected to diminish, and it is crucial to foster their self-sufficiency in learning (Huang, 2018). The nature of adult-child interactions bears resemblance to the process of scaffolding in construction, wherein the support is gradually dismantled as the building advances (Du & Yuan, 2021). Scaffolding-assisted teaching involves the provision of ample support and resources by the teacher to students during the initial stages of their learning process, with the aim of facilitating their comprehension of a given subject matter. Once students attain the expected level of proficiency, the teacher gradually reduces their involvement and support, allowing the learners to take charge of their learning (Coffman, 2022). Furthermore, empirical studies have indicated that the utilization of visual aids enhances the capacity to retain information (Watkiris, 1962). Empirical evidence suggests that incorporating visual demonstrations into teaching practices can enhance students' comprehension and retention of essential concepts, surpassing the effectiveness of traditional lecture-based instruction. The use of visual aids, including but not limited to images, models, slideshows, and videos, has been found to be particularly efficacious in facilitating student learning. The present lesson study delves into the concept of contextual scaffolding as an instructional approach. This method involves the utilization of visual aids by the teacher to establish contexts for the subject matter, thereby facilitating the active engagement of students in classroom learning. Additionally, this approach aims to enhance the students' ability to independently construct their own geographic knowledge structure.

Processes of Classroom Instruction in the Middle East Based on Contextual Scaffolding

Lesson Introduction Supported by Video Presentations

The teacher used multimedia equipment to play videos about conflicts, protests, and refugee camps, and then asked students to identify the locations of all of these events. Based on their prior knowledge of the Middle East, the majority of students were able to identify that the events were occurring there. Students were shown additional videos on conflicts, such as the Iran-Iraq War, Gulf War, Iraq War, and Israel-Palestine Conflicts. Students viewed these videos with a great deal of focus and interest. The teacher then inquired as to why the Middle East has historically been a geographical center. Why have individuals fought in ceaseless wars? This engaging, heuristic introduction to the lesson is intended to integrate students into the subject's contexts and inspire their motivation for further inquiry.

Classroom Inquiry along a Virtual Tour Route

The teacher presented a cartographic representation of the globe to the students, illustrating the Middle East's geographical location at the confluence of Asia, Africa, and Europe and its proximity to the Arabian Sea, the Red Sea, the Mediterranean Sea, the Black Sea, and the Caspian Sea. Considering its distinctive geographical location, the students were directed to embark on a tour of the Middle East.

The First Destination: Medina

The Islamic holy city of Medina is where the students saw some strange things happen. One of these was the fondness for white robes among the male residents. One of the colors that Arabs prefer is white. Most of their structures have a white aspect, and a male Arab traditionally wears a loose white robe with a white headscarf. The scenario with the "beds on housetops" is another intriguing one. The majority of traditional homes in the Middle East have flat roofs, and at night, people frequently sleep on the rooftops of these homes. The teacher then posed the following inquiry: Why do Arabs favor sleeping on roof tops and wearing white clothing? What kind of weather is most common in the Middle East? What are the characteristics of this climate type in terms of temperature and precipitation, using Medina as an example? Students were also given a climate classification map of the world (**Figure 1**) to aid in their analysis.

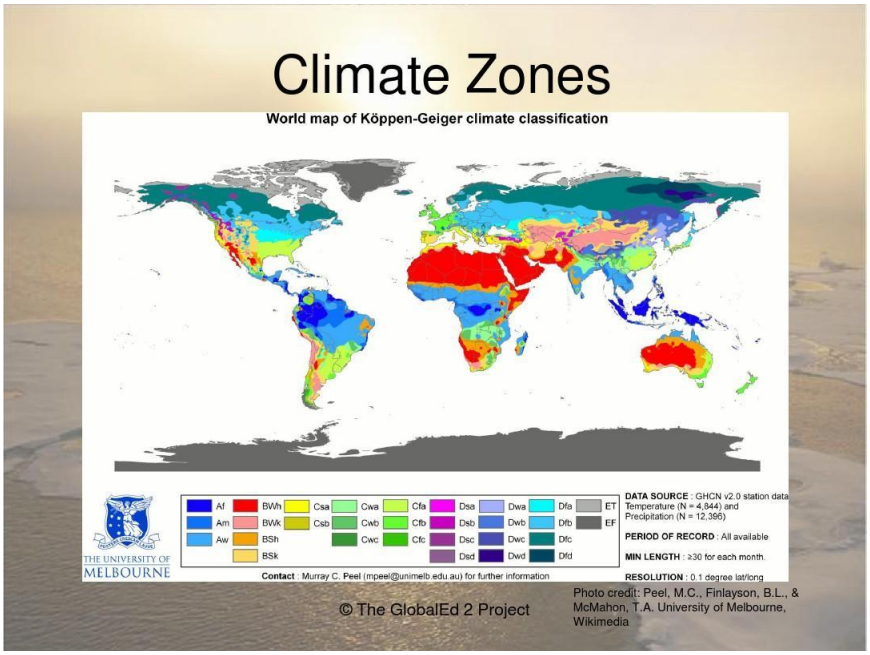

Figure 1. A World Map of Climate Classification.

Figure 2. A Picture of the Wailing Wall.

Through the implementation of concrete situations, relevant questioning, and effective visual aids, the teacher effectively fostered autonomous inquiry, independent thinking, and the efficient acquisition of geographical information among the students. Based on the cartographic representation, it was observed by the students that tropical desert climatic conditions are prevalent in most of the regions situated in the Middle East, encompassing the city of Medina. In regions characterized by elevated temperatures and minimal precipitation year-round, inhabitants tend to exhibit a preference for white clothing due to its high reflectivity against sunlight, thereby reducing heat transmission. Additionally, sleeping on rooftops is a common practice in such regions, as it affords protection from rain and a cooler environment during the night. The climatic attributes of the area result in a severe deficit of water and the ensuing competition for water resources, which is among the factors contributing to the disorder in the region.

The Second Destination: Jerusalem

The Wailing Wall served as the excursion's high point. The teacher described the history of the wall while displaying a picture of it to the class (**Figure 2**). David founded the Kingdom of Israel in the eleventh century BC, with Jerusalem as its capital. The Beit HaMikdash (commonly known as the First Temple) was constructed in the 10th century BC by Solomon, David's heir apparent, as a place of worship for Jehovah, the God of Judaism. The First Temple was destroyed during the Babylonian conquest in 586 BC, and more than 40,000 Jews—including craftsmen, priests, and members of the royal family—were captured and brought to Babylon as slaves. Jews returned to their own land after a half-century of exile, where they erected the Second Temple over the ruins of the First Temple. The temple was once again destroyed in the year 70, under the rule of the Roman Empire; most Jews were driven from their homes, and thousands were massacred. The Roman emperors erected a wall around the Second Temple's ruins. Jews were not permitted to visit their country more than once a year on the Sabbath until the Byzantine Empire. Many Jews arrived at the sacred location and sobbed against the wall. This is the reason this wall is known as the Wailing Wall.

Students were required to hold group talks about the following issues after "visiting the Wailing Wall":

- What Jewish tradition can be connected to the image of the Wailing Wall?
- Why do Jews value the wall so highly?
- Do you believe that the Wailing Wall is a symbol of conflict as well as a historical and cultural wall? Justify your position.

- (Extension question: What other religions consider Jerusalem to be a holy city in addition to Judaism?)

In the extension phase, more details were provided regarding the joint declaration that Saudi Arabia and Iran signed on March 10, 2023, announcing that the two countries had accomplished a historic reconciliation. Students learned about Saudi Arabia's significance as a major nation among Sunnis from a video presentation, while Iran is the foremost nation for Shiites. Tensions between the two nations increased as a result of the numerous disagreements between the two factions regarding their standing and Islamic principles.

The student selected religious disputes as one of the causes of the unstable conditions in the Middle East based on their knowledge of Jerusalem's status as the holiest city for Islam, Judaism, and Christianity, as well as the intense rivalries that exist between various sects of Islam. The teacher effectively created the scaffolding for students to explore the historical and cultural causes of the current conflicts in the Middle East by providing background information on the Wailing Wall and the Saudi Arabia-Iran reconciliation. This is effective training on how to infer fundamental issues from phenomena.

The Third Destination: The Ghawar Oil Field

The teacher guided the students to the largest onshore oil field in the world, which Saudi Arabia discovered in the Persian Gulf Basin in 1948, using an image of the Ghawar oil field (**Figure 3**). Here, the students discovered yet another strange occurrence: oil is more affordable than water. The Middle East has a serious water deficit, but it also has large oil reserves, and oil extraction has long been the region's main industry.

Based on the oil production data provided by the teacher, the students ascertained the primary oil-producing nations in the Middle East and succinctly outlined the key features of their oil sector, which include substantial reserves, elevated yields, and massive exports. The oil export route map provided insight to students regarding the predominant transportation method of oil extracted from the Middle East, which is primarily conveyed via sea to regions such as East Asia, North America, and western Europe. The pivotal significance of the region's oil production in the advancement of the global economy, coupled with the substantial reliance of Arabian nations' economies on the oil industry, are fundamental factors that necessitate students' comprehension of the fact that the pursuit of oil has been a primary catalyst for the conflicts in the Middle East.

The Fourth Destination: Dubai

Figure 3. A Picture of the Ghawar Oil Field.

Figure 4. A Modern Landscape of Dubai

The teacher showed a photo of Dubai in the United Arab Emirates as the final stop on the voyage (**Figure 4**), which depicts a very different landscape from that of the traditional oil-producing regions in the area. Students received an introduction to Dubai's growth in the tourism, aviation, real estate, and financial services sectors, as well as the shift in Middle Eastern countries' attitudes regarding oil resources. Students were also inspired to consider the topic of sustainable development by discussions over whether the area

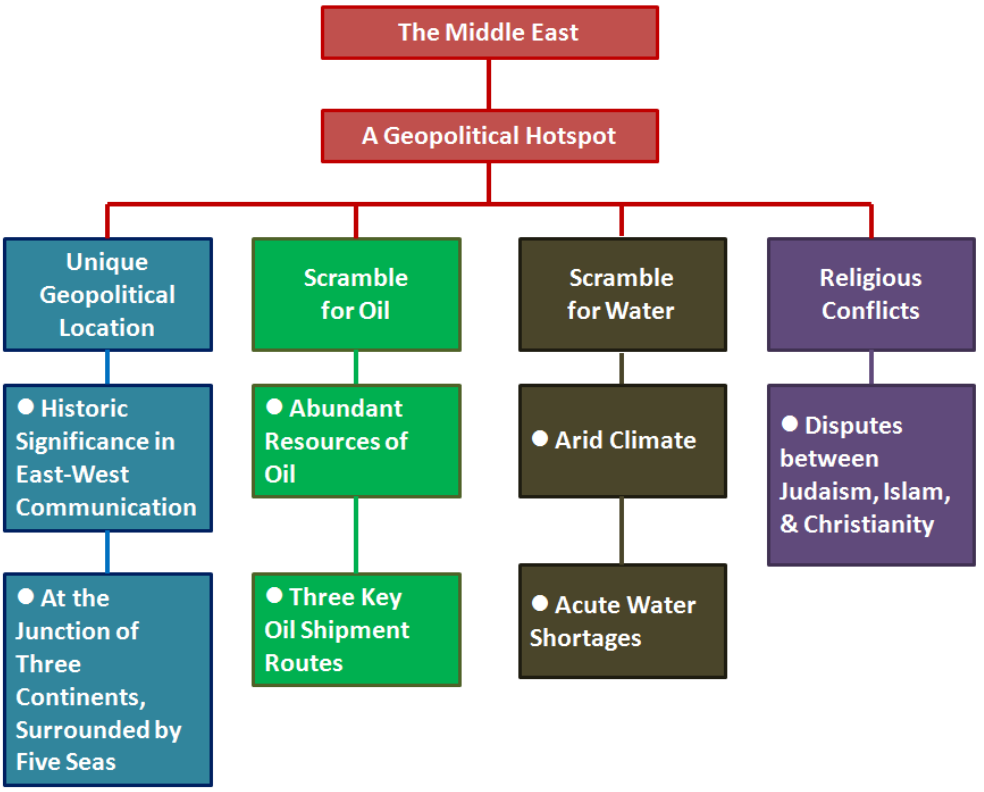

Figure 5. An Example of the Mind-Map by the Student.

should extend its exploitation of oil, an exhaustible resource, in order to gain more income.

Students' Review of Their Middle East Journey

Students were asked to conduct group discussions and give group presentations to highlight their key learning from the classroom inquiry activities. One illustration of their portrayal is shown below.

- The Middle East's crucial geopolitical relevance is determined by its unusual geographic location (at the meeting point of three continents and encircled by five seas).
- The dry, scorching environment of Medina and the ensuing paucity of water resources are indicated by the white robes and mattresses on the tops of the houses there.
- The Wailing Wall in Jerusalem is a representation of the regional disputes resulting from religious and cultural divisions.

- The Ghawar oil field is a sign of the oil wealth of the area. From ports in the Persian Gulf, the great bulk of crude oil is transported to the rest of the world along three primary routes.
- Dubai is a metaphor for the region's efforts at sustainable development and its economic diversification plan.

Each student was also obliged to individually produce a mind map reflecting their knowledge of the Middle East. As students advanced through the course, the teacher gradually withdrew support until, by the time they reached the mind-mapping stage, they were perfectly capable of doing the assignment on their own. Their mind maps are shown in **Figure 5**.

The Teacher's Reflections

The most recent curriculum program and the Double Reduction policy have introduced novel demands for effective pedagogy and student learning. The efficacy of classroom instruction is contingent upon the active participation of students. The incorporation of visual aids, such as maps, slides, and videos, has proven to be an effective strategy in generating students' interest in the subject matter during the course of this lesson. The immersive virtual journey through the Middle East has effectively fostered student engagement through dynamic exploration and profound educational experiences. The teacher gradually decreased the level of assistance provided to the students, allowing them to ultimately construct an independent mind map of the topic. The utilization of mind-mapping as a technique enabled students to independently organize novel ideas and establish their own cognitive framework, thereby fostering the development of structured thinking abilities. The inclusion of the recent occurrence of the "historic reconciliation between Saudi Arabia and Iran" was intended to foster students' consciousness of the importance of being attentive to real-world circumstances in addition to the prescribed course materials. The present instructional session constituted an initial trial in the execution of the novel curriculum program. The subject matter under consideration exhibits certain constraints. In order to enhance student agency during classroom inquiry, it is recommended that the teacher mandate students to independently generate questions based on the given contexts.

References

Coffman, S., Iommi, M., Morrow, K. (2022). Scaffolding as active learning in nursing education. *Teaching and Learning in Nursing*, 18(1):232-237. DOI: https://doi.org/10.1016%2Fj.teln.2022.09.012

Du, D & Yuan, R. Z. (2021). Building a concrete scaffold as a visualization path to stimulating geographic thinking in students: A lesson study of the instruction of the Loess Plateau in grade-8 geography. *Teaching Research for Primary and Secondary Schools*, 22(6):8-11.

Huang, L. (2018). The principles and strategies of the scaffolding teaching approach in geography education: An analysis of the lesson on Natural Characteristics and Agriculture in the Qinghai-Tibet region. *Education of Geography*, 2018(10):53-54.

Watkiris, O. C. (1962). Classroom techniques with visual aids. *Education + Training*, 4(11):20-21. DOI: https://doi.org/10.1108/eb015202

Received: 10 April 2023
Revised: 30 April 2023
Accepted: 09 May 2023

REVIEW

The Application of the 5E Instructional Model in Chinese Basic Education

Peiyu Gu

Nanjing Normal University of Special Education, Nanjing 210038, China

***Abstract**: The 5E instructional framework is a pedagogical approach that consists of five distinct phases, namely engagement, exploration, explanation, elaboration, and evaluation, which together form a comprehensive learning cycle. Each stage denotes a crucial instructional process. The objective of the model is to facilitate the development of a robust knowledge base among students through their active engagement. This paper provides an overview of the historical development of the 5E Model and evaluates its application in the context of Chinese elementary education. The aim is to offer valuable insights into this educational strategy for teachers in the Chinese basic education system.*

Science Insights Education Frontiers 2023; 16(1):2445-2455.
Doi: 10.15354/sief.23.re115

How to Cite: Gu, P. (2023). The application of the 5E instructional model in Chinese basic education. Science Insights Education Frontiers, 16(1):2445-2455.

***Keywords:** 5E Instructional Model, Learning Cycle, Basic Education, Classroom Instruction*

***About the author**: Peiyu Gu, Nanjing Normal University of Special Education, Nanjing 210038, China. E-mail: 354953165@qq.com*

***Correspondence to**: Peiyu Gu in Nanjing Normal University of Special Education of China.*

***Conflict of Interests**: None*

THE 5E instructional model, also referred to as the 5E Model, was formulated by the Biological Sciences Curriculum Study (BSCS) in 1987. The 5Es represent a sequential framework for instructional design and learning that encompasses five distinct phases: engagement, exploration, explanation, elaboration, and evaluation. The teaching methodology in question is based on the principles of constructivism, a learning philosophy that highlights the active participation of students in constructing their own knowledge (Wang & Li, 2012). According to Bybee et al. (2006), BSCS conducted an empirical investigation that revealed that the 5E Model surpasses conventional teaching models in terms of stimulating students' curiosity towards learning and enhancing their academic performance. The phenomenon has garnered significant acknowledgement from educational communities worldwide. Currently, with the ongoing curricular reform in China, inquiry-based learning has emerged as a fundamental principle in the new national curriculum program and course standards. The 5E Model, a successful inquiry-based methodology, has been extensively tested in the context of basic education in China. The present study conducted a comprehensive review of the historical development of the 5E Model and provided an overview of its practical and theoretical implications for front-line educational practitioners in Chinese basic education.

Background of the 5E Instructional Model

The 5E instructional model can be traced back to the Atkin-Karplus learning cycle, which was proposed by Myron Atkin and Robert Karplus in the early 1960s, when Karplus presided over the "Science Curriculum Improvement Study" (SCIS) project as part of the second round of primary science education curriculum reform. Atkin and Karplus argued that a successful learning cycle should consist of three stages: exploration, invention, and discovery. Students acquire new knowledge through relatively unstructured exploration experiences. Following the phase of exploration, the phase of invention allows for the interpretation of newly acquired information through the reorganization of prior concepts. In the discovery phase, the new concept is applied to a novel situation. After Lawson et al. modified the terminology in the 1980s, the three terms became exploration, term introduction, and concept application. Despite variations in terminology, the conceptual basis of the learning cycle has remained largely unchanged (Bybee, 2006).

Midway through the 1980s, BSCS developed a new science and health curriculum for primary schools and recognized the value of students' prior knowledge and the evaluation of the concept-construction process. As a result, the engagement and evaluation stages were added to the Atkin-Karplus learning cycle (Bybee, 2006). The engagement stage of the 5E Model learning cycle is when the teacher pre-assesses the students' prior

knowledge, and the evaluation stage is where the students' learning results are examined. Exploration, explanation, and elaboration, the middle three components of the 5E Model, are essentially the same as the three stages of the Atkin-Karplus learning cycle. The 5E Model, which has its roots in constructivist theory and is closely related to the traits of student cognitive development, was a key component of the new curriculum at BSCS. It broadens the use of an effective teaching strategy that can be used in a curriculum, a particular course, or a particular lesson (Wu & Zhang, 2010).

Early in the 21st century, transnational collaboration, the labor market, and living environments became more complex. In response to the challenges of the 21st century, the U.S. academic community advocated the development of "21st century skills" as additional reform requirements. The research of Bybee (2009) suggested that the 5E instructional model could positively influence the development of 21st century skills in students by fostering their competencies in adaptation, communication, problem-solving, and self-regulation, among others.

The National Academies of Sciences, Engineering, and Medicine of the United States issued the Next Generation Science Standards (NGSS) in 2013 to satisfy the demands of economic development and increase the competitiveness of American education. Its introduction marked a turning point in U.S. science education. The Next Generation Science Standards emphasize that learning is a developmental and exploratory process and that instruction should incorporate three dimensions: disciplinary fundamental ideas, science and engineering practices, and crosscutting concepts. NGSS strongly recommends that teachers integrate the 5E Model into classroom instruction by tactfully designing science and engineering practical activities to promote the development of student competence through science education (Liu, 2014). In the years that followed, the 5E Model has been implemented by teachers across the globe in their teaching designs of various disciplines, such as chemistry (Yadigaroglu & Demircioglu, 2012), physics (Ergin, 2012), biology (Sickel & Friedrichsen, 2015), and nursing (Jun et al., 2013), in an effort to promote meaningful learning in students and the attainment of educational objectives.

Since the introduction of the 5E Model to China at the beginning of the 21st century, Chinese educational researchers have endeavored not only to disseminate the theory and methodology of this instructional model but also to implement it in teaching practices. Research on the application of the 5E Model was conducted at all levels of education in China, from primary to higher education. The preponderance of existing research has focused on its application to basic education classroom instruction.

Ma's (2002) article entitled "*The 5E Instructional Model in American BSCS Textbooks*" represents the inaugural theoretical investigation of the 5E Model in China. The article offers an interpretation of the theoretical under-

pinnings and implementation procedures of this pedagogical approach. Yuan (2004) provided a comprehensive account of the functions of the five stages in the 5E Model and demonstrated the application of this model to classroom instruction through the analysis of the section "Decomposition and Utilization of Organic Substances: Respiration." Dai and Yao (2008) provided an in-depth analysis of the Atkin-Karplus learning cycle's three stages. They utilized the teaching of "photosynthesis" in junior secondary biology as a case study and put forth practical recommendations for the implementation of the learning cycle model. In their study, Wu and Zhang (2010) expounded on the fundamental constituents and utilization of the 5E Model in the context of instructing "Functions of Respiration" in secondary-level biology. They also provided a summary of the model's crucial attributes. The connotations of the 5E Model were analyzed by Wang and Li (2012), who emphasized its implications for science education in China. They recommended utilizing the model to its fullest potential in prior knowledge assessment, exploratory ability cultivation, and science concept construction.

The rapid curriculum reform over the past few years has made the 5E Model research in China more discipline-focused, highlighting its importance in lesson planning. Deng and Liu (2011) integrated teaching strategies such as situation creation, role-playing, and group discussion or cooperation with the 5E Model in the biology classrooms to teach students how to reject underage drinking. Their hands-on investigation demonstrated that 5E education was successful in attaining its teaching goals. In their respective lessons on "Cell Differentiation," "Observational Experiment of Stomata," and "DNA Replication," Fu and Yang (2014), Luo (2015), and Tao (2017) used the 5E Model to identify students' prior knowledge, design inquiry activities to promote the transformation of preconceptions, and help students comprehend and construct new concepts. In order to encourage student science thinking in geography education, Wang et al. (2019) used the methods of the 5E instruction to design the simulative experiment of river topography. This gave students the chance to investigate the effects of river erosion and river-related accumulation on topographic development.

Basic Components of the 5E Model and Their Application in Chinese Basic Education

Engagement

In the 5E learning cycle, the engagement stage's goal is to establish contexts for students to become personally invested in the lesson while simultaneously pre-evaluating their knowledge of the topic at hand. As opposed to scientific notions, prior concepts are also referred to as premature concepts.

Due to the limitations of the students' prior knowledge, these conceptions are generally based on the students' past experiences rather than the facts of the matter. Learning activities at this stage should aim to clarify students' misunderstandings, arouse their curiosity and cognitive conflicts, and establish links between prior and current learning experiences.

Chinese teachers in basic education demonstrate a notable understanding of generating stimulating contexts to elicit students' interest in learning during the engagement phase when implementing the 5E instructional framework. Kong (2012) conducted a study on the implementation of the 5E learning cycle in senior secondary chemistry education. During the engagement stage, students were presented with a current event of significant interest and were prompted to identify chemistry-related topics and generate inquiries. In the engagement stage of a junior secondary mathematics lesson, Yuan (2022) utilized a scenario from the classical novel The Journey to the West as a context for exploration. The author posed pertinent questions to guide students in identifying the variables in the subject and to stimulate their curiosity regarding the relationships between the variables. This approach effectively increased the students' engagement in the lesson. The utilization of contextualization in the implementation of the 5E Model during classroom instruction can effectively stimulate students' engagement in the subject matter, as observed in Chinese teaching practices. Nonetheless, their failure to demonstrate an awareness of the potential for revealing students' preconceived notions and inciting cognitive dissonance among them was evident. It is noteworthy that the identification of students' pre-existing misconceptions and the subsequent creation of cognitive disequilibrium are fundamental components of the learning process. This approach serves as an effective strategy to facilitate proactive learning and promote a comprehensive understanding of scientific concepts among students.

Exploration

Inquiry-based activities are created to give students the chance to take part in studies or experiments during the exploration period. They give students plenty of time for contemplation and imagination with the inclusion of both individual and group exploratory activities. In the exploration phase, the teacher's function is that of a coach or facilitator. It is imperative to conduct experiments using real-world materials and situations. Students begin the basic process of creating scientifically accurate notions by establishing relationships, observing patterns, and questioning events because of their mental and physical involvement in the activity.

In the majority of case studies of 5E instruction conducted by Chinese researchers, the exploration stage is used to formally introduce the concepts, processes, and skills and to guide students in conducting exploratory

experiments. During the exploration stage of the "Combustion and Fire Extinguishing" case study, for instance, the teacher provided a definition of combustion prior to the students' experimentation and then instructed them to conduct experiments according to the textbook's design and his additional explanations (Wu & Liu, 2012). In Yan's (2022) investigation of a physics lesson, the teacher posed a series of questions as the framework for cooperative student experiments, thereby guiding the students' exploration. Therefore, during the exploration phase of the 5E model, Chinese students must follow their teachers' instructions on how to conduct their research, and there is no opportunity for students to conduct independent experiments. Or classroom inquiry devolves into the routine execution of experiments outlined in textbooks. These are not genuinely autonomous exploration activities in which students have no idea of the purpose of their experiments and no expectation of making new discoveries. The essence of the exploration stage is to encourage students to actively pursue solutions to the cognitive conflicts that arose during the engagement stage. The purpose of the current stage's inquiry activities is to cultivate students' interests in scientific explorations and help them comprehend the exploratory process from query to evidence to conclusion.

Explanation

The explanation stage serves the purpose of affording students a platform to articulate their comprehension of the subject matter hitherto assimilated and to decipher its significance. Initially, students are prompted to engage in discourse and provide their own interpretations. Subsequently, the teacher presents scientific justifications in a clear and structured manner. The explanations provided by both students and teachers serve as a mechanism for organizing the exploratory experiences. The primary objective of this phase is to effectively communicate concepts, processes, or skills in a concise and straightforward manner and subsequently proceed to the subsequent stage.

The explanation stage is most frequently used by teachers in Chinese 5E instruction scenarios to help students identify incorrect conceptions or immature perceptual knowledge and to establish scientific notions. To show the generality of new concepts, teachers explain specific situations using new notions. Based on the students' experiences in the exploration stage, the teacher described pertinent phenomena and concepts in the lesson study "Combustion and Fire Extinguishing" and summarized the conditions for combustion (Wu & Liu, 2012). In the example study of a physics lecture by Xiong (2012), the teacher provided more precise explanations of events and improved definitions based on close readings of ideas from the explanation stage. But as the 5E Model is used more frequently, it becomes clear that, in order to get an appropriate answer, teachers' explanations have received far

too much attention while students' opinions have gone unnoticed. Many teachers made an effort to enhance the explanation stage so that student communication would take center stage. In more recent trials, the teacher gave students more chances to demonstrate their own understandings and even encouraged them to repeat experiments to ensure the accuracy of their understandings (Guan, 2021; Yan, 2022). Teachers should probe further, revise students' explanations, and assist learners in making sense of unfamiliar ideas.

Elaboration

In the elaboration stage, students develop previously taught ideas, link them to other ideas that are similar, and use their newly acquired knowledge in novel ways. During this stage, teachers might give students the chance to participate in additional activities that elaborate or extend the concepts, procedures, or abilities and make it easier for them to apply those ideas in new contexts.

During the elaboration stage, Chinese teachers primarily emphasize providing students with opportunities to apply their acquired knowledge and facilitating the cultivation of a more profound comprehension. Frequently, teachers provide students with supplementary extension activities or present a set of novel inquiries to solidify their comprehension prior to assessment. During the elaboration phase of his physics course, Guan (2021) instructed his students to apply their recently acquired knowledge to analyze topics such as "forces acting on railway tracks" and "vehicles traversing an arched or concave bridge." Fu and Chen (2022) instructed their chemistry students to utilize their understanding of the "surface tension of liquids" to elucidate the fundamental principles that govern the construction of bottle openings for essential balm. By means of these instructional practices, teachers directed their students to apply novel concepts or competencies to tackle problems or elucidate phenomena in novel scenarios, thereby enabling them to acknowledge the anticipatory and explanatory potential of fresh concepts in diverse contexts.

Evaluation

The evaluation stage serves the purpose of enabling students to engage in self-evaluation of the extent to which learning and comprehension have been achieved. The process is continuous and diagnostic in nature, enabling the teacher to assess whether the students have met their learning goals. According to the 5E Model, the process of evaluation and assessment can take place at any stage of the learning process and can be integrated throughout all four preceding stages. Teachers could assess students' comprehension and im-

plementation of novel ideas, as well as shifts in their affective dispositions, through both formal and informal evaluation techniques. During this interim period, teachers can also avail themselves of opportunities to assess their own pedagogical practices.

Most Chinese teachers can actively participate in evaluating both the learning process and the learning results of their students throughout the evaluation stage. No matter what responses students provide in the initial lesson period, the teacher typically exerts favorable assessments initially to ensure that their motivation to learn is not destroyed and then guides them to modify their responses through other approaches. The teacher evaluated the students' learning process and learning outcomes in the lesson study on "Combustion and Fire Extinguishing" using both qualitative and quantitative methods (Wu & Liu, 2012). In some instances, the teacher includes the students' peer and self-evaluations in addition to their own ratings. For instance, Cao (2022) used appropriate software in her physics class to include information technology into evaluation. She included digital self- and peer-assessment to help students review new material and provided feedback on students' responses via the teacher's online evaluation.

Conclusion

As research into the 5E instructional model becomes more in-depth, voices have been raised about its limitations, and other models, including the 6E, 7E, and 4E x 2 models, have been adapted from it. The 7E instructional model was proposed by adding the elicitation stage before the engagement stage of the 5E model and inserting the extension stage between the elaboration stage and the evaluation stage to emphasize the significance of exposing students to their prior knowledge and transferring new information (Eisenkraft, 2003). Some researchers argued that students are not sufficiently involved in the explanation phase and, as a result, proposed inserting the expression phase between the explanation and elaboration phases so that each student has the opportunity to demonstrate their learning gains and correct any misconceptions formed in the previous phases. Teachers can use formative assessment in the expression stage to determine whether or not students have attained learning objectives and to assess their teaching effectiveness. This is the origin of the 6E model (Duran et al., 2011). In addition, attempts have been made to incorporate formative assessment, inquiry learning, and metacognition theories into the 5E instructional model in order to develop the 4Ex2 Model, in which assessment and reflection are implemented on all phases of engagement, exploration, explanation, and elaboration. The 4Ex2 Model is intended to assist teachers in focusing on formative assessment and designing exploratory activities of a higher order (Marshall, 2009).

A close examination of the 5E model and its variations, however, reveals that it is a framework that is comparatively comprehensive and already includes the components that the 6E, 7E, and 4Ex2 models assert to supplement. A link analogous to the expression stage that the 6E model adds is present in a regular 5E model. It happens at the explanation stage of the 5E model, where both the teacher's explanations and the students' expression of ideas are prioritized. Similar to the elicitation and extension processes proposed by the 7E Model, the 5E Model's engagement stage entails exposing students' preconceptions and existing knowledge structures through concrete situations, and the elaboration stage also includes the extension of new knowledge. The 5E Model's evaluation stage is broken down into the 4Ex2 Model's assessment and reflection phases, which are then incorporated into each of the preceding four processes. In actuality, the evaluation step of the 5E Model gives equal weight to both teaching and learning reflections as well as assessments of the learning process and outcomes.

Despite all efforts to modify it, the 5E instructional model continues to be a classic and essential teaching method with irreplaceable theoretical and practical value in basic education. First, it can arouse students' curiosity for learning and encourage their active participation. Second, through inquiry-based learning, students acquire a deeper understanding of the material, thereby enhancing their learning outcomes. Third, the 5E Model can effectively cultivate innovative thinking and practical skills in students. It is anticipated that the 5E learning cycle will have greater application potential in basic education classroom instruction. In addition, it is important to note that when implementing the model, the actual learning situation and student characteristics must be taken into account, and teachers must possess the necessary teaching skills and experience to maximize the role of this learning cycle in student development.

References

Bybee, R. W. (2009). The BSCS 5E instructional model and 21st century skills. Colorado Springs, CO: BSCS, 24.

Bybee, R. W., Taylor, J. A., Gardner, A., Van Scotter, P., Powell, J. C., Westbrook, A., & Landes, N. (2006). The BSCS 5E Instructional Model: Origins, Effectiveness, and Applications. Colorado Springs BSCS. Available at: http://science.education.nih.gov/houseofreps.nsf/b82d55fa138783c2852572c9004f5566/$FILE/Appendix%20D.pdf

Cao, M. D. (2022) The application of 5E instructional model in the junior secondary physics class: Using the "Reflection of Light" teaching as an example. *Physics Teaching*, 44(8):29-32.

Dai, M., & Yao, B. J. (2008). The application of

the 5E learning cycle in biology instruction. *Biology Teaching*, 2008(7):18-19.

Deng, Q. P., & Liu, E. S. (2011). Applying the 5E instructional model to the teaching design of "Refusing Under-age Drinking." *Bulletin of Biology*, 46(1):28-30. DOI: https://doi.org/10.3969/j.issn.0006-3193.2011.01.011

Duran, E., Duran, L., Haney, J., & Scheuermann, A. (2011). A learning cycle for all students. *The Science Teacher*, 78(3);56-60. Available at: http://people.uncw.edu/kubaskod/sec_406_506/classes/class_6_planning/learning_cycle.pdf

Eisenkraft, A. (2003). Expanding the 5E model. The Science Teacher, 70(6):56-59.

Ergin, I. (2012). Constructivist approach based 5E model and usability instructional physics. *Latin-American Journal of Physics Education*, 6(1);14-20.

Fu, X.,, & Yang, W. Y. (2014). Applying the 5E instructional model to the teaching design of "Cell Differentiation." *Bulletin of Biology*, 49(7):29-31.

Fu, Y. D., & Chen, L. W. (2022). The teaching design for senior secondary physics based on the 5E instructional mode: A lesson study of the "Surface Tension of Liquid" teaching. *Physics Teachers*, 43(1):6-11.

Guan, B. D. (2021). The classroom teaching design for Senior secondary physics based on the 5E instructional model. *Teaching Reference of Middle School Physics*, 2021(21):50-51.

Jun, W. H., Lee, E. J., Park, H. J., Chang, A. K., & Kim, M. J. (2013). Use of the 5E learning cycle model combined with problem-based learning for a fundamentals of nursing course. *Journal of Nursing Education*, 52(12):681-689. DOI: https://doi.org/10.3928/01484834-20131121-03

Kong, Y. (2012). Practice and exploration of the 5E learning cycle in senior secondary chemistry teaching. *Chemistry Teaching and Learning*, 2012(3):43-45+35

Lin, F. Q., & Yao, D. W. (2007). An evaluation of 5E instruction, a constructivist teaching model: A lesson study of "Free Fall." *Educational Practice and Research (Secondary School Edition)*, 2007(5):51-53.

Liu, X. R. (2014). The framework and characteristics of the U.S.'s New Generation Science Standards. *Studies in Foreign Education*, 2014(5):115-122.

Luo, X. F. (2015). The teaching design of senior secondary biology experiments based on the 5E instructional model. *Biology Teaching*, 40(11):45-47.

Ma, W. K. (2002). The 5E instructional model in American BSCS textbooks. *Primary and Secondary Schooling Abroad*, 2002(4):39-40. DOI: https://doi.org/10.3969/j.issn.1007-8495.2002.04.007

Marshall, J. C., Horton, B., & Smart, J. (2009). 4E × 2 instructional model: Uniting three learning constructs to improve praxis in science and mathematics classrooms. *Journal of Science Teacher Education*, 20(6):501-516. DOI: http://dx.doi.org/10.1007/s10972-008-9114-7

National Academies of Sciences, Engineering, and Medicine. (2013). Next Generation Science Standards: For States, By States. Washington, DC: The National Academies Press. DOI: https://doi.org/10.17226/18290

Sickel, A. J., & Friedrichsen, P. J. (2015). Beliefs, practical knowledge, and context: A longitudinal study of a beginning biology teacher's 5E unit. *School Science and Mathematics*, 115(2):75-87. DOI: https://doi.org/doi:10.1111/ssm.12102

Tao, Y. J. (2017). The application of the 5E instructional model to the teaching of core concepts of secondary biology: An analysis of the instruction of "DNA Replication." *Middle School Biology*, 2017(12):27-30.

Wang, J., & Li, X. J. (2012). The components of the 5E instructional model and their implications for science education in China. *Bulletin of Biology*, 47(3):39-42.

Wang, T, Dai, W. Y., & Chen, Q. Y. (2019). The Application of the 5E instructional model to geographic experiment teaching: Using the simulative experiment of river topography as an example. *Geography Teaching*, 2019(20):4-7.

Wu, C. J., & Zhang, M. (2010). The components, examples, and essential characteristics of the 5E instructional model in American biology education. *Curriculum, Teaching Material and Method*, 2010(6):108-112. DOI: https://doi.org/10.19877/j.cnki.kcjcjf.2010.06.024

Wu, X. L., & Liu, J. J. (2012). The Application of the 5E learning cycle in junior secondary chemistry teaching. *Chinese Journal of Chemical Education*, 33(5):28-30. DOI:

https://doi.org/10.3969/j.issn.1003-3807.2012.05.009

Xiong, T. Z. (2012). Teaching Design for the instruction of "Multimeters" based on the 5E instructional model. *Sciences and Wealth*, 2012(2):2.

Xue, X. Y., Cai, C., & Ma, L. F. (2010). Educational Theories and Strategies. Zhenjiang: Jiangsu University Press. 2010.

Yadigaroglu, M., & Demircioglu, G. (2012). The effect of activities based on 5E model on grade 10 students' understanding of the gas concept. *Procedia-Social and Behavioral Sciences*, 47:634-637. DOI: https://doi.org/10.1016/j.sbspro.2012.06.709

Yan, L. M. (2022). The classroom teaching design for senior secondary physics based on the 5E instructional model. *Asia-Pacific Education*, 2022(14):4-6.

Yuan, T. Z. (2022). The teaching of Junior secondary mathematics concepts based on the 5E instructional model: Citing the lesson on "Variables and Functions" as a case study. *Teacher Education Forum*, 35(12):58-60.

Yuan, W. X. (2004). The 5E instructional model and its application in biology education. *Biology Teaching*, 2004(5):10-11.

Received: 03 April 2023
Revised: 23 April 2023
Accepted: 06 May 2023

REVIEW

Internet Addiction among College Students in China and Its Underlying Causes

Xuyue Xia

Zhenjiang Technician College, Zhenjiang 212113, Jiangsu, China

***Abstract**: The internet's rapid development has fundamentally altered human society. While the internet has provided human with unprecedented convenience and efficiency and has become crucial to their lives, learning, and work, it has also created a number of social challenges, including internet addiction. Multiple studies have been carried out from diverse viewpoints to investigate the topic of internet dependency among children. Based on an analysis of prior studies, the purpose of this paper is to present an overview of internet addiction among Chinese college students, explain its causes, and summarize its detrimental effects in order to provide recommendations for future research on the subject.*

Science Insights Education Frontiers 2023; 16(1):2457-2473.
Doi: 10.15354/sief.23.re127

How to Cite: Xia, X. (2023). Internet addiction among college students in China and its underlying causes. Science Insights Education Frontiers, 16(1):2457-2473.

***Keywords:** Internet, Addiction, China, College Students, Causes*

***About the author**: Xuyue Xia, Zhenjiang Technician College, Zhenjiang 212113, Jiangsu, China. E-mail: 616636896@qq.com*

***Correspondence to**: Xuyue Xia, Zhenjiang Technician College of China.*

***Conflict of Interests**: None*

THE Internet is considered the fourth principal mass medium, following newspapers, radio, and television. As a consequence of the rapid development of information technology, the Internet has become an increasingly essential tool for people's daily lives. *The 50th Statistical Report on China's Internet Development* published by the China Internet Network Information Center (CNNIC) in August 2022 revealed that as of June 2022, China had an internet penetration rate of 73.0% and 1.051 billion internet users, which accounted for approximately one-fifth of the global total; that each user spent an average of 29.5 hours per week online; and that the 10–19 age group accounted for 13.5% of the total internet users and the 20–29 age group for a similar percentage. The report also revealed that students were the largest category of Internet users in China, accounting for 25.1%, with college students comprising the largest proportion (CNNIC, 2022).

According to Mo (2018), college students, who possess a higher level of education and are more open to adopting new technologies, have effectively established internet usage as a mainstream cultural phenomenon on their respective campuses. The internet has emerged as the primary information resource for individuals. One can expeditiously access the requisite information via search engines such as Baidu and Google and access scholarly literature by logging into electronic libraries across the globe. The internet serves as a crucial medium for interpersonal communication, unbound by temporal and spatial limitations. In addition, it offers a variety of entertainment options for college students. As per Yang and Chen (2006), individuals have the option to engage in activities such as streaming music or movies online, downloading multimedia content from the internet, or sharing their own collection with acquaintances. Consequently, the ubiquitous nature of the internet has permeated all aspects of the lives of university students. Deng et al. (2022) conducted a survey on the internet usage patterns of students in medical junior colleges in Jiangxi Province. The sample size consisted of 1106 students. The results indicated that 51.72% of the participants spent between 3 and 6 hours online daily, while 3.07% of them spent more than 9 hours online every day. The study also revealed that 49.55% of the students used the internet for recreational purposes, 35.26% used it for socializing, 28.12% used it for information search, and 18.72% used it for online shopping. The outcome of this survey aligns with the conclusions drawn in CNNIC's report (CNNIC, 2022).

Unquestionably, the Internet is extremely beneficial to the personal and academic development of college students. However, college students can abuse its interactivity, interconnectivity, anonymity, accessibility, and low cost (Tao, 2005). Some of them have squandered a great deal of time and effort by chatting and playing online games in an aimless and unre-

strained manner, eventually becoming addicted to the internet, which has had a devastating effect on their lives and studies.

An Overview of Internet Addiction among Chinese College Students

Definition of Internet Addiction

The phenomenon of internet addiction was initially introduced by Ivan Goldberg in 1994. Goldberg characterized it as a condition in which the individual spends an excessive amount of time online with an unreasonably high frequency and is unable to regulate this compulsive behaviour. Furthermore, individuals who suffer from this addiction may exhibit withdrawal symptoms if they are prevented from accessing the internet (Cui & Zhao, 2004). Subsequently, the phenomenon of internet addiction has garnered significant attention within the realm of psychology. Young (1998) refined the definition of pathological gambling by incorporating the diagnostic criteria outlined in the Manual for the Diagnosis and Statistics of Mental Disorders, as established in 1996. It was underscored that pathological utilization of the internet is a type of impulse-control disorder that does not entail the use of an intoxicant. Additionally, Young emphasized the four characteristic indications of internet addiction, which include compulsive usage, withdrawal, tolerance, and the associated outcomes of dependence on the internet. An internet addiction diagnosis questionnaire consisting of eight items was developed based on the four dimensions. Young proposed that individuals who respond affirmatively to five or more of the eight questions should be categorized as internet dependents or addicts.

In 2005, Tao and his colleagues at the China Youth Psychological Development Center developed the Clinical Diagnostic Criteria for Internet Addiction Disorder (hereafter referred to as the Criteria), utilizing a sample size of 1200 clinical cases and tens of thousands of clinical data points. As per the established criteria, internet addiction is classified as a mental-behavioural disorder that arises from excessive usage of the internet. Individuals who suffer from this condition exhibit a compulsive urge to repeatedly use the Web and display various mental and physical symptoms, including withdrawal symptoms, when their cyber usage is curtailed or terminated (Tao et al., 2008).

College students who use the internet frequently are more likely to develop an internet addiction. When internet penetration is 100% among them, the rate of internet addiction detection is comparatively higher than it is among other categories. Hsieh et al. (2019) found a 17% internet addiction detection rate among college students in Taiwan Province; Wang et al. (2019)

surveyed a sample of college students from eight universities in Kunming City and found that 10.7% of them were addicted to internet use; and Ren et al. (2019) found 10.40% and Cao et al. (2019) found 8.33% internet addiction detection rates among college students in Xinjiang Province and Northeast China, respectively. According to a meta-analysis of 26 studies, 11% of Chinese college students were found to have internet addiction in 2018, with a modest rising tendency in the early years but a progressive stabilization in the last three years (Shao et al., 2018).

Categories of Internet Addiction Disorders among Chinese College Students

The phenomenon of internet addiction encompasses a diverse range of behavioural issues. The initial attempt to classify internet addiction disorders was made by Young (1999), a researcher in the field. A survey was conducted using a questionnaire to gather data from 44 therapists who had an average of 14 years of clinical practice. The participants reported having treated a minimum of nine individuals with cyber addiction in their caseload. According to the therapists' report, a significant proportion of their clients utilized various online platforms for communication and entertainment purposes. Specifically, 80% of the clients used email, 70% engaged in chat rooms, 10% utilized newsgroups, 30% participated in interactive online games, and 65% accessed the World Wide Web, primarily for viewing pornography or utilizing online trading or auction house services. Young's categorization of cyber disorders is based on clinical data obtained from respondents. The five categories identified by Young are cyber-sexual addiction, cyber-relationship addiction, net compulsions, information overload, and computer addiction. Despite minor variations in cyber behaviour among college students, Young's classification remains largely relevant to their problematic internet usage. The most notable forms of internet addiction among Chinese college students include addiction to internet entertainment, particularly internet gaming, internet pornography, internet relationships, cyber information overload, and online transactions.

Internet Entertainment Addiction

Among Chinese college students, internet entertainment addiction is the most prevalent manifestation of cyber disorder. The internet has the capacity to integrate various media forms, such as text, graphics, audio, and videos, to generate distinctive outcomes. University students have the ability to derive sensory pleasure through engaging in online gaming, music listening, and video watching. This activity simultaneously fulfils their psychological de-

sire to express autonomy and distinctiveness. In accordance with Yu et al. (2022), individuals tend to exhibit greater dedication towards internet entertainment as they encounter increased levels of online stimulation.

The World Health Organization officially recognized internet gaming disorder (IGD) as a form of addiction disorder in 2019, thereby classifying it as a mental illness (Huang, 2020). In line with Mihara and Higuchi's (2017) systematic review of 50 studies conducted worldwide, the prevalence of internet gaming disorder on a global scale was found to range between 0.7% and 0.75%. The recreational activity of online gaming is prevalent among college students on the internet. According to the 50th Statistical Report on Internet Development in China, as of June 2022, the number of online game users in China was 552 million (CNNIC, 2022). Based on Chen's (2007) survey on the internet usage of college students, 40% of respondents reported that their primary reason for accessing the internet was to engage in online gaming. A significant factor contributing to the reliance of college students on online games is the ability of players to establish social connections and attain a sense of accomplishment and prestige by collaborating with others in the simulated realm of video games, thereby experiencing a feeling of esteem and acknowledgement. Zhang (2022) conducted a study at a university located in Tianjin, China, which revealed that 8.67% of students were addicted to online games. The prevalence of gaming addiction among freshmen, sophomores, juniors, and seniors was 4.20%, 13.25%, 15.84%, and 7.8%, respectively. The majority of student addicts, 60.58%, played online games between 14 and 20 times per week. Furthermore, 71.15% of them played online games almost every day, and 81.73% spent more than 5 hours gaming per day.

Internet Pornography Addiction

Pornographic text, audio, video, images, ads, and more are all examples of internet pornography. Most college students are between the ages of 18 and 24 and have a strong innate urge for sex. Their compulsive fascination with adult chat rooms, pornographic websites, or virtual sex, which is motivated by their sexual urges, leads them to develop an addiction to internet pornography (Yuan, 2004). Traditional pornography is distributed in a very different manner than internet porn. The internet cannot be sanitized with the capacity for network supervision now in place. On the internet, college students can explore pornographic images, watch pornographic movies, and seek out pornographic material at any moment (Xia & Sun, 2020). Nearly half of Chinese college students have visited pornographic websites, and a sizable percentage of them have become fascinated with online pornography, according to the East China Normal University report on the Survey on College Students' Internet Morality (Dong & Dai, 2003). It is important to rec-

ognize the negative effects of internet pornography. The conventional sexual morality of college students has been seriously eroded by the massive volumes of unhealthy sexual information that is being broadcast online, which has even resulted in violent sex-related situations.

Internet Relationship Addiction

The proliferation of the internet has led to a substantial transformation in the methods of interpersonal communication. Du (2018) has established that a social network of "human-machine-human" has been formed in cyberspace. The realm of cyberspace has the potential to obscure the distinctions between virtual reality and tangible reality while simultaneously expanding the social horizons of university students. This can foster a greater willingness to engage in interpersonal communication and facilitate the discovery of individuals who share similar interests. As a result of the anonymity afforded by the internet, college students exhibit a greater propensity to confide in their online acquaintances and express emotions that they may feel compelled to suppress in face-to-face interactions. Over a period of time, it is possible to develop a dependency on online relationships. In the words of Cai (2017), there are instances where virtual communication is expanded to include face-to-face interaction. Notwithstanding, a subset of college students exhibit an inability to limit their internet communication to a moderate extent and frequently participate in prolonged online conversations throughout the night, thereby resulting in significant disturbances to their daily routine (Wang & Hu, 2013).

Cyber Information Overload

Through the utilization of the internet, college students are able to access a plethora of information sources that offer extensive amounts of knowledge and encompass a broad spectrum of subject matter. According to Huang and Shen (2011), the internet has eliminated temporal and spatial limitations on information retrieval, thereby broadening the intellectual boundaries of college students. Conversely, individuals may find themselves susceptible to becoming disoriented amidst a plethora of distracting and multifarious online content, leading to a deviation from their original intent and an inadvertent inundation of extraneous information. Accordingly, Tao (2007) found that a significant proportion of college students, approximately 70%, engage in the habitual practice of perusing information that is deemed unnecessary. Frequently, individuals encounter a predicament when utilizing computers to retrieve scholarly data, as they may inadvertently come across irrelevant information, such as entertainment news and gossip, owing to the presence of various distractions, including links, advertisements, and pop-up windows.

This, in turn, leads to a significant loss of time that could have been utilized for studying and resting, ultimately resulting in a decline in academic performance.

Online Transaction Addiction

College students who engage compulsively in online trading, auctions, and purchases are said to have an online transaction addiction. Online shopping has the benefits of being convenient, time-efficient, and free from external influences. In the age of consumerism, it better satisfies the hedonistic urge and has altered traditional purchase patterns (Chen, 2012). Chinese consumers have access to a wide range of products thanks to online marketplaces like Taobao and JD.com. Their psychological demand for individuality is also satisfied by the freedom inherent in online shopping. College students are particularly prone to making pointless purchases because they are so fascinated by the excitement of internet shopping. In addition, simple access to online loan platforms exacerbates their excessive shopping, pushing their living expenses over their planned spending limits (Yang, 2015). These factors combine to keep their urge for consumption stimulated. The worst part is that some college students are unable to control their purchasing urges and end up ruining their lives by getting caught in financial traps like online usury.

The Hazards of Internet Addiction for College Students

Internet addiction is a serious societal problem that can lead to a variety of physical and mental issues in college students. It impedes not just the long-term advancement of the entire country but also the personal growth and progression of college students.

Impaired Physical Health

According to existing studies, the majority of college students who are internet addicts go on for ten hours or more each day. The physical health of an individual might be severely harmed by prolonged, excessive internet use. College students who spend a lot of time in front of screens, particularly those who are addicted to online gaming, frequently develop visual impairments. The light on the screen of online games is constantly flickering, requiring the player to adjust their vision over time. The eye lens will eventually get overworked, which can increase students' myopia and, in severe situations, lead to retinal detachment (He, 2020). In addition, sedentary be-

haviour associated with internet use can lead to more severe conditions affecting the neck and lumbar spine, as well as shoulder and back muscle strain. Additionally, the daily pattern is upset among college students who use the internet excessively, which causes them to lose their appetite, sleep less, and have a thrown-off biological clock. Physical sub-health that persists can easily lead to numerous diseases or even unexpected death (Wang, 2012). More than 70% of internet-dependent students experience vision loss, nerve dysfunction, shoulder and back muscular strain, and reduced immunity, according to Song et al.'s (2011) survey findings.

Decline in Academic Performance

The internet offers a vast array of educational resources to college students, fostering the cultivation of divergent thinking and promoting awareness of innovation. Therefore, Chinese institutions of higher education prioritize the enhancement of students' internet literacy. In order to guarantee the availability of internet connectivity for college students, the government has made significant investments in the development of campus network infrastructure (Dai & Zhang, 2015). Nevertheless, certain college students do not effectively utilize it by prioritizing the enhancement of their academic accomplishments. Conversely, individuals tend to engage in non-academic activities on the internet. Consequently, their school attendance becomes irregular, and their inclination towards academic pursuits diminishes. A significant proportion of students experience academic setbacks, such as failing exams, which may result in repeating academic years or discontinuing their studies altogether. A survey conducted by the Institute of Psychology at the Chinese Academy of Sciences in 13 colleges and universities in China revealed that approximately 80% of school suspensions and dropouts were attributed to internet addiction (Yuan, 2018).

Degenerated Cognitive Ability

Yang (2009) notes that the rapid dissemination of online news and the coinciding of major events result in a condensed timeframe for college students to receive copious amounts of information. Nevertheless, the immediate alteration of information is unlikely to leave a profound impact on the cognitive faculties of the receiver. When students have not yet fully processed recently acquired information, a significant influx of new information can impede their ability to internalize the material and disrupt the typical cognitive processes of the brain. Many college students engage in aimless browsing of substandard information on the internet and extensive but disjointed online reading. Limiting one's comprehension to a superficial level can hinder the

ability to engage in profound thinking. With the passage of time, their cognitive capacity will experience a decline.

Weakened Social and Emotional Competences

Some college students lose interest in social life in the real world as a result of long-term immersion in entertaining and stimulating virtual reality. This can result in mental and psychological issues such as identity confusion, emotional apathy, depression, and value distortion (Wang, 2012). College students who are pathologically dependent on the Internet are more likely than their peers to have psychological disorders such as depression, paranoia, anxiety, withdrawal, impulsiveness, and violent tendencies (Liu et al., 2006). Sociality is innate in humans. Interpersonal interaction in the real world is a crucial way for college students to socialize. The indirect human-machine-human mode of interaction online has largely replaced "face-to-face" interpersonal communication for student internet consumers (Bian, 2016). They have fewer opportunities for direct social interaction the longer they spend time online. Alienation from society is associated with a variety of social and emotional issues.

Degraded Morality and Values

College students are in a crucial stage of developing their perspective, values, and morality. Internet characteristics such as decentralization, openness, and virtuality pose significant obstacles to moral education (Yin, 2014). Existing moral norms are not inherently applicable to regulating online behaviour (Rao, 2005). According to Tao (2007), there is a prevalence of moral relativism and anarchism, moral apathy, and severe online malfeasance among college students who are internet addicts. The most prevalent immoral behaviour among them is lying. They lie to their instructors about their absence from class, and they lie to their parents about the amount of time they spend online and the purposes for which they use the internet. Internet consumers are able to conceal their true identities in cyberspace, giving them the impression that they are free to say or do whatever they please, which compromises their integrity and sense of responsibility. According to Xu et al. (2010), adolescents who are overly dependent on online activities are more likely to exhibit personality disorders and deviant behaviour. Some students spend a significant amount of money filling up their accounts in order to gain more experience in the game, resulting in massive debts that may lead to criminal behaviour.

Causes of Internet Addiction among College Students

Multiple factors influence the addictive behaviour of college students on the Internet. It is the interaction between individual personality attributes, stimulus sources, and the environment. Environmental factors include parenting style, domestic environment, schooling, and socially prominent cultures. Students with a dearth of self-control are susceptible to the temptations posed by the Internet. Personality traits are effective predictors of internet dependence, given that the current rate of internet penetration among college students is 100%, but not all of them become excessively dependent on the cyber world.

Characteristics of the Internet

The Internet is distinct from all other media due to its accessibility, anonymity, virtuality, interactivity, and efficiency. The internet provides a platform for young people to obtain experiences that are difficult to attain in real life. Chen and Huang (2008) believe that the Internet's unique characteristics can adequately meet the requirements of adolescents for interpersonal communication, social support, and self-actualization. In online games, for instance, they can freely express their emotions and experience a sense of accomplishment; in online chat rooms, they can confide in someone. The virtual and indirect nature of internet communication reduces their vigilance and alertness, allowing them to feel at ease and candid online. The internet has become an indispensable component of college students' lives, and for some, it is existence itself.

High Efficiency of Internet Information Transmission

The internet's ability to operate instantaneously and overcome temporal and spatial limitations results in its high efficacy, which coincides with the imperative for college students to acquire knowledge pertaining to current and sensitive social matters. According to Huang (2009), this approach satisfies the individuals' requirement for a thorough comprehension of the global scenario within a reasonable timeframe. Additionally, it provides them with the chance to engage in cross-regional communication with their contemporaries. The aforementioned circumstance has inevitably exerted a significant influence on the mannerisms and conduct of university students.

Tremendous Amounts of Internet-Based Information

The internet is a highly open and inclusive platform that offers a vast array of information across diverse fields of human endeavour. This makes it an indispensable tool for college students who are actively engaged in a quest for knowledge. The diverse range of captivating entertainment materials, in-

cluding hit songs and blockbuster movies and TV shows, has presented an alluring allure for university students. To derive greater enjoyment from these materials, individuals may progressively increase their time spent browsing the internet, leading to the development of an excessive reliance on them.

Free Flow and Interactivity of Online Communication

The internet's inherent freedom and interactivity are perfectly suited to young people's interest in emotional connection. In their study, Zhang et al. (2006) point out that information acquisition and interpersonal emotional engagement make up the two main components of college students' motivation for utilizing the internet. According to Huang (2002), one of the primary drivers of online communication is to meet psychological requirements. Online emotional engagement and people's desires for love, respect, and a sense of community are intimately intertwined. A key contributor to the emergence of internet addiction is the use of the internet for emotional communication.

Virtuality and Anonymity of the Cyber World

Young college students with a strong desire to rebel against moral restraints find the virtual cyberspace to be the perfect social setting. The internet's lack of social constraints gives people the chance to indulge latent urges that are against accepted social norms, making it a safe haven for those who are feeling stressed out by pressures from the outside world (Yan, 2013). Internet users enjoy numerous types of pleasure in cyber communication, including the pleasure of anonymity, activity, risk-taking, avoidance, etc., according to Zhou and Zhou (1997). Online entertainment keeps people interested and may even cause internet addiction.

Personality Traits Associated with Internet Addiction

Studies have examined the relationship between college students' personality features and online addiction and found that factors including introversion, sadness, privateness, and social phobia are important indicators of cyber illnesses. Students who demand more attention and have severe social anxiety are more likely to develop an internet addiction, according to research by Professor Qian at Peking University (Zhou, 2003). In contrast to non-internet-dependent college students, internet-dependent students have a higher propensity for withdrawal, despair, and anxiety, according to Jiang and Gu's (2005)

A variety of symbols are used to symbolize individuals in the virtual world of the internet. For their online identities, college students can "design" their appearance, personality, age, educational background, and even gender. Less confident students tend to enjoy themselves more online, which leads them to spend more time there and try to forget about the actual world. They will be overcome by dissatisfaction and loneliness once their internet activity is stopped. As a result, people would purposefully increase their online time during subsequent internet usage, creating a vicious cycle (Yang, 2004). Additionally, college students who tend to avoid face-to-face interaction with society are more likely to develop an online addiction (Guan, 2021). They will eventually have trouble determining their true selves, experience greater loneliness and suffering, and feel even more cut off from the real world because they may hide their true identities in cyberspace and assume any temporary roles they choose.

Family-Related Factors

The association between a child's online behaviour and their relationship with their parents has been linked by research. Children are more likely to turn to the internet for emotional gratification and comfort when parents fail to form a close relationship with them and the latter cannot sense parental warmth (Wang, 2022). In households with young internet addicts, strict parenting is typical, finds a study by Zhou et al. (2008) on home satisfaction and college students' internet addiction. Children raised in this manner may get severe punishments for even little infractions, be subjected to rigid rules, and receive little parental praise and encouragement. On the other hand, some parents might embrace a laissez-faire approach to their kids' upbringing and be minimally involved in their development. Internet dependence is more likely to emerge in children raised by unsatisfactory parents.

Furthermore, in our rapidly evolving society, the disparity between generations continues to expand. Intergenerational conflicts frequently arise due to divergent perspectives and values held by college students and their parents. Given that a significant proportion of students remain financially reliant on their parents, it is probable that they will be at a disadvantage in terms of winning competitions, even if their concepts are more innovative. In this scenario, individuals may opt to discontinue communication with their parents and instead seek refuge in the virtual realm, which serves as their utopia.

School-Related Factors

Internet addiction on college campuses has been accelerated by the change in the educational environment and students' failure to adjust to new paradigms

of educational management (Liu & Chen, 2009). The size of schools has significantly increased since China started to expand college enrolment in 1999. Its administration system has not necessarily been upgraded to accommodate the increased number of students, either. One of the main contributing factors to internet addiction among college students is the absence of school oversight and internet instruction. The importance of online management has increased, and at the same time, face-to-face interaction between administrators, teachers, and students has been greatly diminished. This poses a significant difficulty for students who lack self-control and self-regulation, since they may spend most of their aimless college years aimlessly browsing the internet.

Social Factors

The lack of adequate internet regulation, the dearth of cultural amenities in the neighbourhood, and the harsh environment in which young people must survive are social factors that contribute to online addiction among college students (Tao, 2007). Internet-related difficulties include unfiltered cyber resources, lax cybercaf ésupervision, inadequate management of online gaming, and other growing issues that are not adequately addressed by the rules and regulations already in place for internet sectors. Facilities that are established in the community do not fit the needs of college students. Their multilevel needs for leisure activities, interpersonal communication, character building, and other cultural activities are not met by the current public cultural institutions. Additionally, students are under a great deal of emotional stress due to the demanding academic load and the bleak employment outlook. They might seize hold of virtual cyberspace to look for feelings of self-worth and accomplishment to escape those pressures from the outside world.

Conclusion

In the current era of rapid transformations and innovations, the internet serves not only as a means of transmitting information and providing entertainment but also as a valuable repository of knowledge. The internet has assumed a significant position in contemporary society and has become an indispensable aspect of college students' lives, serving as a means for information acquisition, social engagement, and leisure activities. However, excessive internet usage can lead to significant social, psychological, and academic dysfunction among individuals. The problem of internet addiction among college students lacks a straightforward resolution. The prevention and correction of this issue necessitate collaborative endeavours from the individual, educational institution, family unit, and broader community. It is recommended that students exhibiting problematic internet dependence re-

ceive intervention and therapy that utilize behavioural reinforcement techniques to facilitate the development of responsible internet usage and promote the restoration of typical college functioning.

References

Bian, W. L. (2016). Self-adjustment of college students with internet addiction. *Shandong Youth*, 2016(8):30-31.

Cai, Y. (2017). The transformation of online group behavior (master's thesis). Shanghai Academy of Social Sciences. Available at: https://kns.cnki.net/KCMS/detail/detail.aspx?dbname=CMFD201801&filename=1017122607.nh

Cao, R. L., Mei, S. L., Hu, Y. Y., Qin, Z. Y., & Zhang, Y. (2019). Relationships between internet addiction and self-esteem and sense of life meaning among college students from three universities in Northeast China. *Medicine and Society*, 2019(6):115-118. DOI: https://doi.org/10.13723/j.yxysh.2019.06.031

Chen, G. L. & Huang, J. M. (2008). Adolescent Internet-related Psychology. Beijing: Communication University of China Press. 2008.

Chen, L. (2007). Causes of internet addiction among college students and prevention and intervention measures. *Private Higher Education Research*, 2007(1):5.

Chen, Z. X. (2012). Strengthening the Supervision of the Quality of Online-sold Goods. *Biweekly of Industrial and Commercial Administration*, 2012(22):72-74.

CNNIC. (2022). The 50th Statistical Report on China's Internet Development. *China Internet Network Information Center*. (2022-08-31). Available at: https://www.cnnic.cn/NMediaFile/2022/0926/MAIN1664183425619U2MS433V3V.pdf

Cui, L. J., & Zhao, X. (2004). Setting criteria for internet addiction using Angoff's method. *Journal of Psychological Science*, 2004(3):721-723. DOI: https://doi.org/10.16719/j.cnki.1671-6981.2004.03.054

Dai, R. Q., & Zhang, F. G. (2015). Pathways to the improvement of internet literacy in college students: Based on the core socialist values. *Journal of Hubei Open Vocational College*, 2015(7):37-38.

Deng, W. H., Wang, L. J., Wang, J, Yang, S. W., & Shi, Y. F. (2022). The current state of internet use and internet addiction among junior college students. *Science & Technology Vision*, 2022(6):127-129. DOI: https://doi.org/10.19694/j.cnki.issn2095-2457.2022.06.40

Dong, H. L., & Dai, S. (2003). A questionnaire survey and analysis of college student online morality and behavior. *Journal of Branch School of Southern Medical University*, 2003(2):129-131.

Du, Q. (2018). The transformation of social ideas in the context of virtual social interaction. *China Journal of Multimedia and Network Teaching*, 2018(7):163-164.

Guan, G. C. (2021). The cultivation of healthy internet mentality in college students from the perspective of cyber ideological security. *Theory and Practice of Contemporary Education*, 2021(4):114-118. DOI: https://doi.org/10.13582/j.cnki. 1674-5884.2021.04.019

He, Y. (2020). The current state of internet addiction among college students and preventive countermeasures: A case study of college students in Jiangsu Province. *Industrial and Science Tribune*, 2020(14):111-112.

Hsieh, K. Y., Hsiao, R. C., Yang, Y. H., Lee, K. H., & Yen, C. F. (2019). Relationship between self-identity confusion and internet addiction among college students: the mediating effects of psychological inflexibility and experiential avoidance. *International Journal of Environmental Research and Public Health*, 16(17):3225.

DOI: https://doi.org/10.3390%2Fijerph16173225

Huang, D. P. (2009). The impact of the internet on college students. *Science Mosaic*, 2009(10):2.

Huang, L. D., & Shen, X. C. (2011). Expand the sources of knowledge and improve the ability to utilize information: The avenues and methods for college students to effectively access internet information resources. *Huaiyin Normal University's Education Science Forum* (Z1).

Huang, S. H. (2002). The game of reshaping oneself: interpersonal communication in the cyberspace. Lanzhou: Lanzhou University Press. 2002.

Huang, S.H., Chen, Y. J., Zhou, Q. A., & Wang, Y. R. (2020). Boredom Proneness and online gaming addiction of university freshmen: The moderating role of meaning in life. *China Journal of Health Psychology*, 2020(4):580-585. DOI: https://doi.org/10.13342/j.cnki.cjhp.2020.04.022

Jiang, N. N., & Gu, H. G. (2005). Online behavior, attitudes, and personality traits of college students. *Journal of Psychological Science*, 28(1):3.

Liu, C. Y., & Chen, Y. H. (2009). An investigation into college student internet dependence: A case study of the survey on internet addiction among students with Renmin University of China. *China Youth Study*, 2009(11):64-67+47. DOI: https://doi.org/10.19633/j.cnki.11-2579/d.2009.11.014

Liu, Q., Zhang, P., Li, R. P., Li, S. J., & Li, S. (2006). The impact of internet addiction on physical and mental health of college students. *Journal of Medical Forum*, 2006(15):18-19.

Mihara, S., & Higuchi, S. (2017). Cross-sectional and longitudinal epidemiological studies of Internet gaming disorder: A systematic review of the literature. *Psychiatry and Clinical Neurosciences*, 71(7):425-444. DOI: https://doi.org/10.1111/pcn.12532

Mo, X. L. (2018). The impact of the internet on the identification with mainstream culture in college students and coping measures. *Think Tank Era*, 2018(29):2.

Rao, C. P. (2005). The Legal System for the Internet. Beijing: People's Court Press. 2005.

Ren, T. T., & Liu, J. (2019). Internet addiction among Kazakh college students in Xinjiang agricultural and pastoral areas and influencing factors. *Modern Preventive Medicine*, 2019(11):2004-2008.

Shao, Y. J., Zheng, T., Wang, Y. Q., Liu, L., Chen, Y., & Yao, Y. S. (2018). Internet addiction detection rate among college students in the People's Republic of China: A meta-analysis. *Child and Adolescent Psychiatry and Mental Health*, 12(1):1-10. DOI: https://doi.org/10.1186/s13034-018-0231-6

Song, J. X., Dong, H. L., & Han, W. Y. (2011). Internet addiction among college students and countermeasures. *Modern Education Management*, 2011(6):94-96. DOI: https://doi.org/10.16697/j.cnki.xdjygl.2011.06.023

Tao, G. F. (2005). Social Psychology of College Students. Shanghai: East China University of Science and Technology Pres. 2005.

Tao, R. (2007). Analysis of internet addiction and intervention. Shanghai: Shanghai People's Publishing House.

Tao, R., Huang, X. Q., Wang, J. N., Liu, C. Y., Zhang, H. M., Xiao, L. J., & Yao, S. M. (2008). The formulation of clinical diagnostic criteria for internet addiction. *Medical Journal of Chinese People's Liberation Army*, 33(10):4

Wang, H. (2022). The influence of parenting style on college student internet addiction and educational countermeasures (master's thesis). Heilongjiang University. Available at: https://kns.cnki.net/KCMS/detail/detail.aspx?dbname=CMFD202202&filename=1022039337.nh

Wang, H. B., & Hu, X. (2013). The current state of college students' online social interaction. *Studies in Ideological Education*, 2013(11):75-77.

Wang, S. M. (2012). The harm of internet addiction to college students and countermeasures. *People's Tribune*, 2012(29):144-146. DOI: https://doi.org/10.16619/j.cnki.rmlt.2012.29.020

Wang, X., Jing, Z. G., & Wan, Z. (2019). The relationship between the family cultural environment and college student internet addiction. *Chinese Character Culture*, 2019(15):154-155. DOI: https://doi.org/10.14014/j.cnki.cn11-2597/g2.2019.15.077

Xia, J., & Sun, S. F. (2020). The governance of online pornographic information targeting

minors. *Journal of Guangzhou Police College*, 2020(3):3-12.

Xu, X. L., Cheng, C. L., & Sun, L. J. (2010). The impact of online games on teenagers. *Journal of Southeast University (Philosophy and Social Sciences)*, 2020(S1):7.

Yan, H. W. (2013). Online Gaming Addiction among College Students (Doctoral dissertation). Nanjing University of Science and Technology. Available at: https://kns.cnki.net/KCMS/detail/detail.aspx?dbname=CDFD1214&filename=1013354378.nh

Yang, M. M. (2015). Factors influencing online shopping addiction of college students (master's thesis). Zhejiang Normal University. Available at: https://kns.cnki.net/KCMS/detail/detail.aspx?dbname=CMFD201601&filename=1015647259.nh

Yang, X. F., & Chen, Z. Y. (2006). The relationships between internet use, internet addiction and mental health of college students (ed.) Proceedings of the 2006 Annual Academic Conference of Chinese Psychological Society's Special Committee of Developmental Psychology and Special Committee of Educational Psychology (pp. 148).

Yang, Z. (2009). Mental health problems of college students in the internet context. *Guide of Science and Education*, 2009(25):109-110.

Yang, Z. J. (2004). Internet-related psychological problems among college students and their causes (master's thesis). Northwestern Polytechnic University. Available at: https://kns.cnki.net/KCMS/detail/detail.aspx?dbname=CMFD9904&filename=2004062941.nh

Yin, J. (2014). The impact of cyber communities on people's views of meaning in life. (master's thesis). Beijing University of Posts and Telecommunications. Available at: https://kns.cnki.net/KCMS/detail/detail.aspx?dbname=CMFD201501&filename=1015526308.nh

Young, K. S. (1998). Internet addiction: The emergence of a new clinical disorder. *Cyber Psychology & Behavior*, 1(3):237-244. DOI: https://doi.org/10.1089/cpb.1998.1.237

Young, K. S., Pistner, M., O'mara, J., & Buchanan, J. (1999). Cyber disorders: The mental health concern for the new millennium. *Cyberpsychology & Behavior*, 2(5):475-479. DOI: https://doi.org/10.1089/cpb.1999.2.475

Yu, C. X., Man, S. Y., & Zhang, T. T. (2022). The impact of online entertainment on college students' study and life and coping measures. *Light and Textile Industries of Fujian*, 2022(10):73-76.

Yuan, D. Z. (2004). College Student Internet Pornographic Behavior and Internet Pornography Addiction (master's thesis). Hunan Normal University. Available at: https://kns.cnki.net/KCMS/detail/detail.aspx?dbname=CMFD0506&filename=2005113556.nh

Yuan, Y. J. (2018). Computerized adaptive test of internet addiction based on multidimensional IRT (master's thesis). Jiangxi Normal University. Available at: https://kns.cnki.net/KCMS/detail/detail.aspx?dbname=CMFD201902&filename=1018090764.nh

Zhang, F., Shen, M. W., Xu, M., Zhu, H. Y., & Zhou, N. (2006). Structural Equation Modeling of Motives, Behaviors of Internet Use and Related Social-Psychological Health. *Acta Psychologica Sinica*, 2006(3):407-413. Retrieved From: https://journal.psych.ac.cn/xlxb/CN/

Zhang, J. L. (2022). The construction of the correction model for college student online gaming addiction: A study based on the survival adaptability project. *Journal of Yancheng Normal University (Humanities and Social Sciences Edition)*, 2022(5):50-59. DOI: https://doi.org/10.16401/j.cnki.ysxb.1003-6873.2022.05.065

Zhou, L, Meng, H. Q., Qiu, H. T., & Zheng, Y. P. (2008). The relationship between college student internet addiction and home satisfaction. *Journal of Chongqing Medical University*, 33(4):4.

Zhou, R., & Zhou, Q. (1997). The relations between internet addiction, internet use behavior and the pleasant experience of communication. *Communication Association of China*, 1997(1):2-12.

Zhou, T. (2003). The relationship between college students' social anxiety and internet addiction. *Journal of Educational Science of Hunan Normal University*, 2003(3):85-87.

Received: 13 April 2023
Revised: 29 April 2023
Accepted: 07May 2023

Science Insights Education Frontiers
pISSN 2644-058X eISSN 2578-9813

Note to Contributors

Science Insights Education Frontiers (SIEF) is published under the auspices of the Bonoi Academy of Science and Education to provide authoritative, critical surveys on the current status of subjects and problems in the diverse fields of education.

We accept manuscripts on every aspects of education. We only accept four types of manuscript: Editorial, Commentary, Short Communication, Article, and Review. Editorial and Commentary are invited perspectives written by our editors and external expert reviewer(s), respectively. Review is solicited and welcomed from the experts in corresponding research fields. All manuscripts should be submitted online (http://bonoi.org/index.php/sief/about/submissions) or E-mail to editorial-office@bonoi.org. In addition, the following suggestions may serve as a general guide.

Authors should note that they are writing for an international audience. National colloquialisms and idiomatic use of language should be avoided to the extent possible. Word choices and sentence constructions that might imply bias against persons on the basis of gender, racial or ethnic group membership, disability, sexual orientation, or age should be avoided.

Manuscripts are accepted for publication subject to copyediting. Manuscript submission indicates the author's commitment to publish in *SIEF* and to give *SIEF* first publication rights. No paper known to be under consideration by another journal will be reviewed.

Judicious selection of references is an important function of the authors. Cited references should be listed alphabetically according to author, and the author's last name and publication year should be used in the text. The full title of each paper should be given. Each citation should be checked with the original publication to avoid embarrassing errors. The system used in the Chemical Abstracts for abbreviations of journal names should be followed.

The length of a paper is no measure of its quality, and it is only the latter that determines acceptability for publication. However, practical considerations make if desirable to set a provisional limit of 10,000 words of the main text that does not include tables, figures, and references; and at least 1,000 words for each accepted paper should have for the main text.

The acceptability of a manuscript cannot, of course, be finally decided until the finished product has been examined. The acceptance is contingent upon the advice of the Editor-in-Chief of the SIEF.

Correspondence relating to editorial matters should be addressed to the editorial office via online contact form.

Science Insights Education Frontiers

pISSN 2644-058X
eISSN 2578-9813
(Monthly)
http://bonoi.org/index.php/sief

ORDER FORM

Start my 2023 print copy subscription to the journal of ***Science Insights Education Frontiers***
pISSN 2644-058X, eISSN 2578-9813

_____$125.00 Author Individual _____
_____$475.00 Non-author Individual _____
_____$2480.00 Institution _____

Sales Tax: 5.75% _____

TOTAL AMOUNT DUE: $_____

Subscription orders must be prepaid. Subscriptions are on a calendar year basis only. Allow 4-6 weeks for delivery of the first issue. We use the same subscription rate internationally.

SEND THIS ORDER FORM TO *(Hard copy only)*
Science Insights Education Frontiers
Insights Publisher
Subscriptions
725 W. Main Street
Suite F, Jamestown
NC 27282, USA

Call **+1 336-528-4762**
Email: **base.publication@basehq.org** *(Send E-copy)*

□ **Check enclosed** (Make Payable to BASE)

Charge me: □ Visa □ MasterCard
□ American Express □ UnionPay

Cardholder Name_____
Card No._____
Exp. Date_____
_____
Signature *(Required for Charge)*

Billing Address
Street_____
City_____
State/Province_____
Zip_____ Daytime Phone_____
Email:_____

Mail To
Name_____
Address_____
_____
City_____
State/Province_____
Zip_____
Country_____

SIEF23

(You can make a copy of this form)

Science Insights Education Frontiers
Vol. 16, No. 1, 2023

pISSN: 2644-058X
eISSN: 2578-9813
DOI: 10.15354/sief

Science Insights Education Frontiers Vol.16, No. 1, May 2023 Insights Publisher