

Developments in Abacus Research

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Abstract

This paper will explore zhusuan (the study and practice of the use of the abacus), China's 30th entry into the Representative List of the Intangible Cultural Heritage of Humanity by the United Nations Educational, Scientific and Cultural Organization (UNESCO), and will look at zhusuan study as a developmental trend in the theory and practice of culture and education. This paper adopts a comprehensive research method that includes literature review and profile analysis. Profile analysis uses the CNKI database as for the scope of its searches to comprehensively review the theory and educational practice of zhusuan study. The research and development of zhusuan study can be roughly organized into three aspects: 1) From courses within the system to education outside of the system; 2) From a cultural view to educational view; 3) From the Han cultural milieu to the cross-cultural sphere. Research on zhusuan study can be divided into three stages: 1) The past: the history and culture of zhusuan; 2) The present: Research on zhusuan culture and education; 3) The future: Research on the integration of zhusuan across separate disciplines. This study believes that: Owing to the transformation of zhusuan theory and educational discourse ecology, zhusuan has expanded from the Han cultural milieu to a cross-cultural sphere, and the educational practice of "mental abacus" has also been integrated across separate disciplines. That being the case, this study suggests that zhusuan research can be developed in three directions: 1) Taking multiple intelligences as its theoretical basis; 2) Taking interdisciplinarity as its research method; 3) Taking lifelong education as its educational discipline.

Keywords

Cultural Education, Interdisciplinary, Multiple Intelligence, Abacus, Lifelong Learning

1. Introduction

On December 4, 2013, UNESCO resolved to include zhusuan in the "Represent-

ative List of the Intangible Cultural Heritage of Humanity”: “Chinese Zhusuan is a time-honored traditional method of performing mathematical calculations with an abacus. Zhusuan is widely used in Chinese life and is an important symbol of traditional Chinese culture, providing a strong sense of cultural identity.” Zhusuan, while being established on the foundation for the study of cultural symbols and mathematics, is also a practical computational science, and it has developed into a comprehensive body of knowledge. Research on zhusuan is diverse and wide-ranging, but few people discuss the developments and trends in zhusuan research itself. Therefore, this paper adopts a comprehensive research method that includes literature review and profile analysis. Profile analysis uses the CNKI database as for the scope of its searches to comprehensively review the theory and educational practice of zhusuan, and thereby investigate the developmental trends in zhusuan research.

2. The Development of Zhusuan

The abacus has been hailed as one of the five great inventions of ancient China (Needham, 1971). And as Nobel Laureate in Physics Dr. Lee Tsung-Dao once said, “The Chinese abacus is the most ancient calculator.” Zhusuan is a computational science with the abacus as its computing tool. “Zhusuan-style mental abacus” is abbreviated herein as “mental abacus.” “Mental abacus” is simply calculation using a mentally visualized abacus. “Zhusuan” and “zhusuan mental abacus” are collectively referred to as “zhusuan mental arithmetic.” The following uses literature review to discuss the development of zhusuan:

2.1. From within the System to Outside of the System

Taiwan promulgated the “Revised Curriculum Standards of Primary Education” in 1936 to include “zhusuan” in the “arithmetic” curriculum for grades four through six; the “National Curriculum Standards of Primary Education” were promulgated in 1993, more than half a century (60 years) later, which removed “zhusuan” from the “arithmetic” curriculum, and complicated calculation textbooks were greatly reduced in number. At the same time, it was stipulated: “An electronic calculator is a necessary learning tool for every student above grade four; schools should also prepare a number of calculators for whenever they may be needed” to reflect social needs of the future. In the same year (1993), it was incorporated into “reform mathematics”, and it began implementation in 1996, up until 2003 when then-Minister of Education Huang Jong-Tsun announced that elementary school mathematics would no longer solely follow “reform mathematics” (Lin, 2017). In the 7 years of implementing “reform mathematics” (1996-2003), the ability to perform general addition and subtraction of many students has seen overall decline. Because school teachers in the system no longer require students to memorize multiplication tables, some students are unable to memorize multiplication tables and unable to perform fast and accurate multiplication and division, leading to the parents sending their children to educa-

tional institutions outside of the system to receive training in zhusuan mental arithmetic. Many educational institutions have introduced zhusuan mental arithmetic teaching into mathematics counseling, and the results have been remarkable (Liao, 2015).

The above-mentioned factors have directly or indirectly promoted the resurgence of zhusuan mental arithmetic education institutions, which has been a sunset industry. Although zhusuan has moved from the school curriculum within Taiwan's education system to educational institutions outside of the system, another wave of zhusuan mental arithmetic has arisen out of this opportunity.

2.2. From a Cultural View to the Educational View

The term “zhusuan” first appeared in a work by Xu Yue (?-220) of the Eastern Han Dynasty, “Notes on Arithmetic Methods”. He says: “As for zhusuan, it binds the four seasons and regulates the three powers.” The book records various ancient Chinese calculation devices in detail. In the painting “Along the River During the Qingming Festival” by painter Zhang Zeduan (1085-1145) of the Northern Song Dynasty, there is a 15-digit abacus visible on the counter of the apothecary Zhao Taicheng. “The Universe on a Pole” by Yuan Dynasty painter Wang Zhenpeng (dates of birth and death unknown) depicts an abacus on the shoulder pole of a merchant. Its beams, rods, and beads are very clear, and its appearance is like a modern abacus. “Zhusuan had become popular among folk in the Yuan Dynasty” (Hua, 1987). The term “abacus” is very abundant in the literature, and can be found in the jing (classics), shi (historical works), zi (philosophical works), and ji (prose and poetry works) (Lin, 2011). The history of zhusuan's development is akin to the life of cultural history. Set against different historical backgrounds, different social conditions, and different cultural contexts, zhusuan has seen its own unique developments and applications. The historical development from “mathematics” as one of the traditional Six Arts of ancient Chinese culture to cultural heritage in the 21st century was not inevitable, but rather telling of the fact that people of different ages have different needs when adapting to life (Lin, 2017).

The cultural view embodied by the abacus (tangible heritage) and zhusuan (intangible heritage), as well as the abacus created by the correspondence between “luoshu” and “mathematics”, echo the “hexadecimal” law of operation unique to Chinese culture, and embodies mathematical calculation within culture, which is the sum of human life. Zhusuan mental arithmetic in the 21st century is not only about mathematics education, but also education in science and culture. Cultural pedagogy is a science that investigates human culture and education; it focuses on the connection between culture and education. Zhusuan study has become an educational discipline. Therefore, this paper proposes the concept of “zhusuan study” as the basis for the study of zhusuan. Zhusuan study itself contains the two theoretical bases of science education and cultural education.

2.3. From the Han Cultural Milieu to the Cross-Cultural Sphere

There was intimate cultural exchange of zhusuan between China and East Asian countries in antiquity (Chen, 2013). The “Banshu Abacus” in Ono City (named Banshu in the Edo Period), Japan, has a production history of more than 400 years. The “Banshu Abacus Museum” houses abaci for the visually impaired, as well as Horie-style abaci and Tokyo-style abaci (Lin, 2017). A batch of zhusuan booklets written in Western languages appeared in the early- and mid-20th century, and introduced the basic operations of zhusuan to non-Chinese readers. These independent English booklets on zhusuan were mainly published, distributed, and disseminated in Southeast Asian countries, China regions like Hong Kong and Taiwan (Zhou & He, 2021). Six years after *The History of the Zhusuan* (Pullan, 1968) was published in the United Kingdom, Masao Shioura translated it as *The History of the Soroban* (1974) and published it in Japan. According to the researcher’s survey and interview: “Countries that currently make abaci in the world include Zhejiang, China; Banshu, Japan; Amsterdam, the Netherlands; and Budapest, Hungary.” (Interviewee: Hidetaka Miyanaaga; Interviewer: Lin Yuhui; Translation: Honda Tamaken; Time: January 2017; Location: Banshu Abacus Museum, Ono City, Japan). It may be seen that the Chinese abacus has not only spread to Asia, but even to Europe.

Not only has the Chinese abacus spread to all parts of the world, international zhusuan education has been promoted in five continents around the world. From the 1980s and 1990s, several heads of Taiwan’s zhusuan education institutions immigrated overseas and started to develop international zhusuan education institutions locally in the United States, Australia, Canada, and other countries (Liao, 2019). In addition, there are many ethnic Chinese who have locally developed international zhusuan education. At present, there are also places in Europe and the United States focusing on zhusuan teacher education and developing zhusuan teacher education certification (Liao, 2019). It may be seen that Chinese zhusuan has expanded to the five continents of the world, and international zhusuan education has garnered no small amount of interest.

According to the researcher’s field investigation abacus courses are still retained in Japan and Malaysia. In primary schools across Japan there are 4 classes per week for third graders and 2 classes per week for fourth graders (surveyed and researched from June 1 to 8 of 2023). Malaysia has included abacus as a compulsory course for first and second grade students since 2005.

On October 28, 2002, the “World Abacus and Mental Arithmetic Federation” was jointly organized by international folk abacus and mental arithmetic education organizations. There are currently 55 member units (countries and regions). Its founding purpose is to promote abacus culture, strengthen exchanges and cooperation among various abacus and mental arithmetic organizations, promote the spread and development of abacus and mental arithmetic education around the world, focus on the enlightening role of abacus and mental arithmet-

ic education, and benefit mankind. Formulate abacus and mental arithmetic grade appraisal, international competitions, and organize international academic exchanges on abacus and mental arithmetic. It can be seen that abacus education plays a global role in culture, education and international exchanges.

3. Research Trends in Zhusuan Study

Steps in the design of the present study: 1) Ten keywords were selected that were closely related to zhusuan; the first eight are simplified Chinese keyword searches, and the last two are English keyword searches of “Chinese abacus” and “zhusuan”. The CNKI database was used as the scope of the search. Topics relevant to the keywords were retrieved, and the largest number of entries for the first three items and the number of entries were obtained (**Table 1**); 2) Retrieved research papers relevant to the keywords and retrieved a “research trend chart” of the annual volume of publications. The last retrieval time of the “research trend charts” given in this paper is: September 30, 2021; 3) Used the profile analysis method to discuss the research trends of zhusuan study.

The ten keywords set by the researcher are: Eight keywords in simplified Chinese (here translated into English): abacus, zhusuan, mental abacus, zhusuan mental arithmetic, zhusuan and mental arithmetic, zhusuan culture, zhusuan teaching, zhusuan education; and two keywords in English: Chinese abacus, zhusuan. As is obvious from the search results in **Table 1**, most of the related research on zhusuan revolves around “zhusuan mental arithmetic”, with ten groups of keywords ranking first; and the one with the most entries is “zhusuan mental arithmetic”, occupying five sets. The eight topics related to the simplified Chinese keyword “zhusuan mental arithmetic” are all on the list, and if not ranked first, at least in second or third. It can be seen that “zhusuan mental arithmetic” has become a general term for zhusuan culture, zhusuan education, and other related theories and practices.

3.1. The Past: The History and Culture of Zhusuan

Research trend chart of the annual volume of publications found by the researcher based on CNKI search keywords, relevant topics, and the number of results (**Table 1**).

Since it is difficult for researchers to completely demarcate among the past, present, and future of research trends, this paper roughly demarcates among three groups of research trend charts. From the research trend chart of the annual volume of abacus-related publications (**Figure 1**), research trend chart of the annual volume of zhusuan-related publications (**Figure 2**), research trend chart of the annual volume of zhusuan mental arithmetic-related publications (**Figure 3**) and research trend chart of the annual volume of zhusuan mental arithmetic-related publications (**Figure 4**), there is an obvious and sharp decline in the number of articles published in 2019, which seems to foretell the shift in research orientation for the future. The ancient past of zhusuan is already in the

Table 1. CNKI search keywords, relevant topics, and the number of results.

Keyword	CNKI search keywords, relevant topics, and the number of results		
	Order	Relevant topic	Number of entries
Abacus	1	abacus	168
	2	Zhusuan mental abacus	131
	3	Zhusuan abacus	68
Zhusuan	1	Zhusuan mental abacus	663
	2	Zhusuan education	425
	3	Zhusuan mental arithmetic education	265
Mental arithmetic	1	Zhusuan mental abacus	1911
	2	Zhusuan mental arithmetic education	596
	3	Zhusuan mental arithmetic education	474
Zhusuan mental abacus	1	Zhusuan mental abacus	1912
	2	Zhusuan mental arithmetic education	596
	3	Zhusuan mental arithmetic education	474
Zhusuan mental arithmetic	1	Zhusuan mental abacus	759
	2	Zhusuan mental arithmetic education	313
	3	Zhusuan mental arithmetic education	176
Zhusuan culture	1	Zhusuan mental abacus	87
	2	Zhusuan mental arithmetic education	72
	3	“An Exploration of Zhusuan and Development of ‘Mental Education Culture in Early-Childhood”	19
Zhusuan education	1	Zhusuan education	425
	2	Zhusuan mental arithmetic education	29
	3	Zhusuan mental abacus	28
Zhusuan education	1	Zhusuan education	73
	2	Zhusuan mental arithmetic education	66
	3	Zhusuan mental abacus	43
Chinese Abacus	1	Chinese	4
	2	abacus	4
	3	children	2
Zhusuan	1	Do We Still Need the Abacus	1
	2	Structural selection	1
	3	Abacus and Mental Arithmetic Facilitates the Tea	1

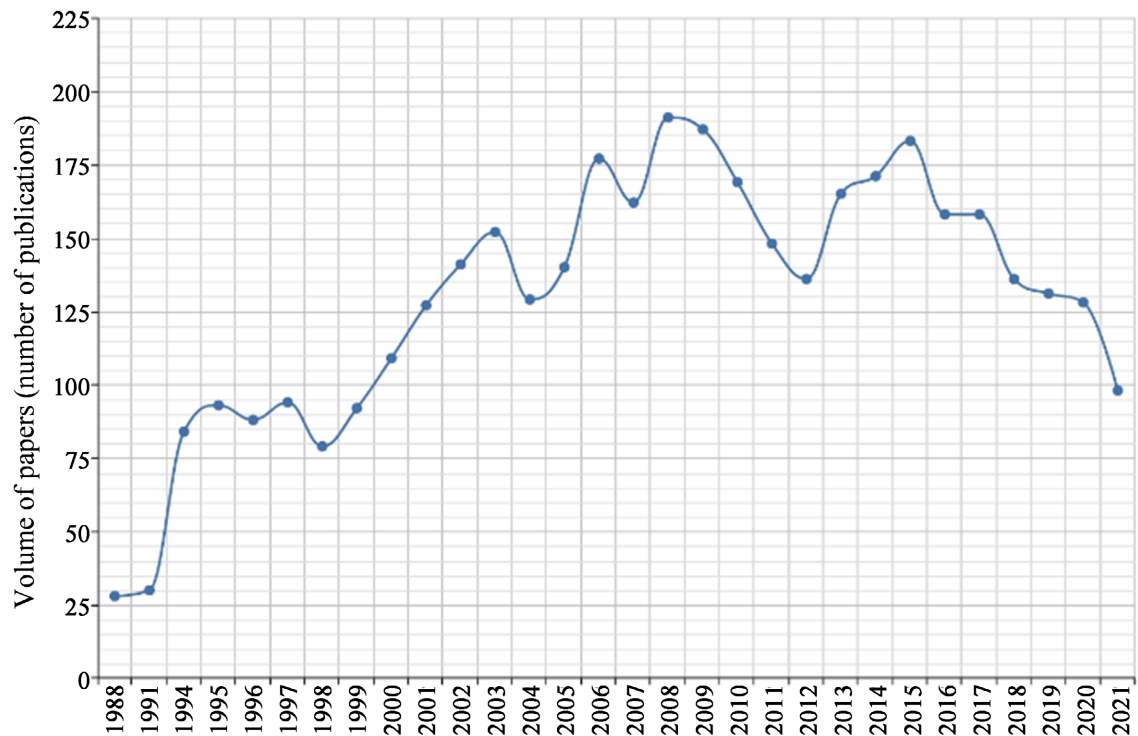


Figure 1. Research trend chart of the annual volume of abacus-related publication.

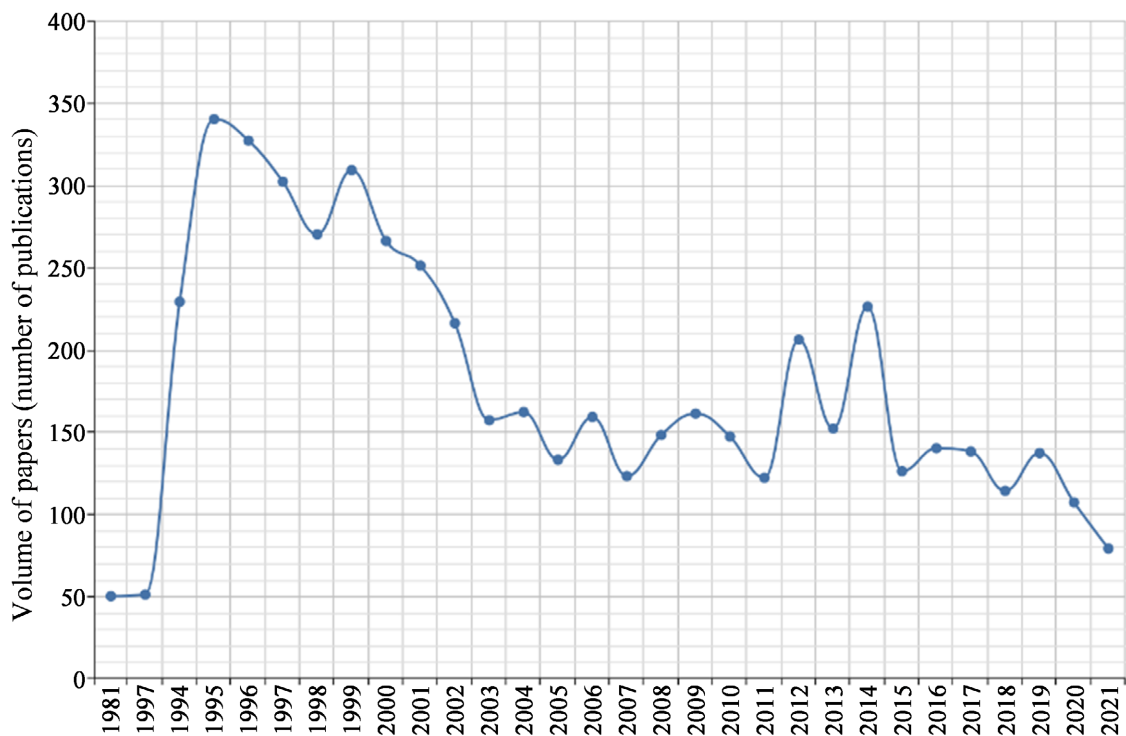


Figure 2. Research trend chart of the annual volume of abacus-related publication.

past, and we today are too late to participate in it. Therefore, we can only learn about the ancient past of zhusuan from extant documents, unearthed cultural relics, and the few remaining zhusuan masters in the world: The history and

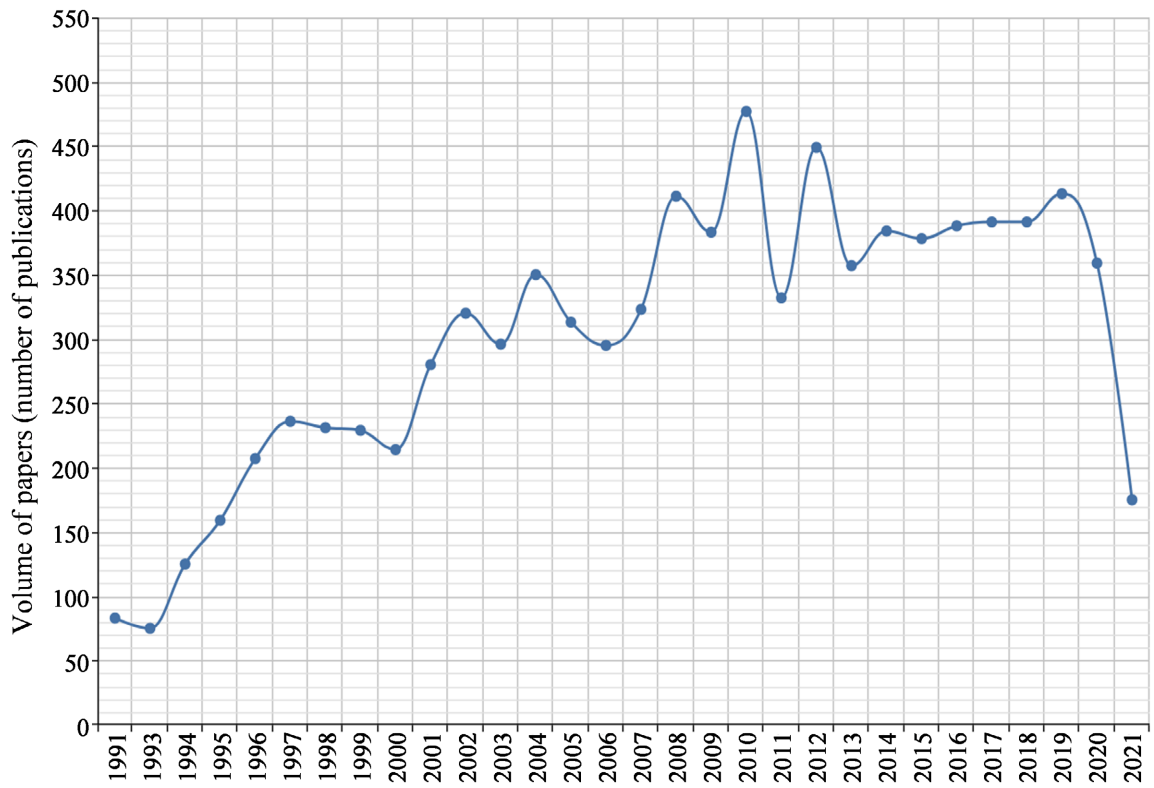


Figure 3. Research trend chart of the annual volume of mental abacus-related publications.

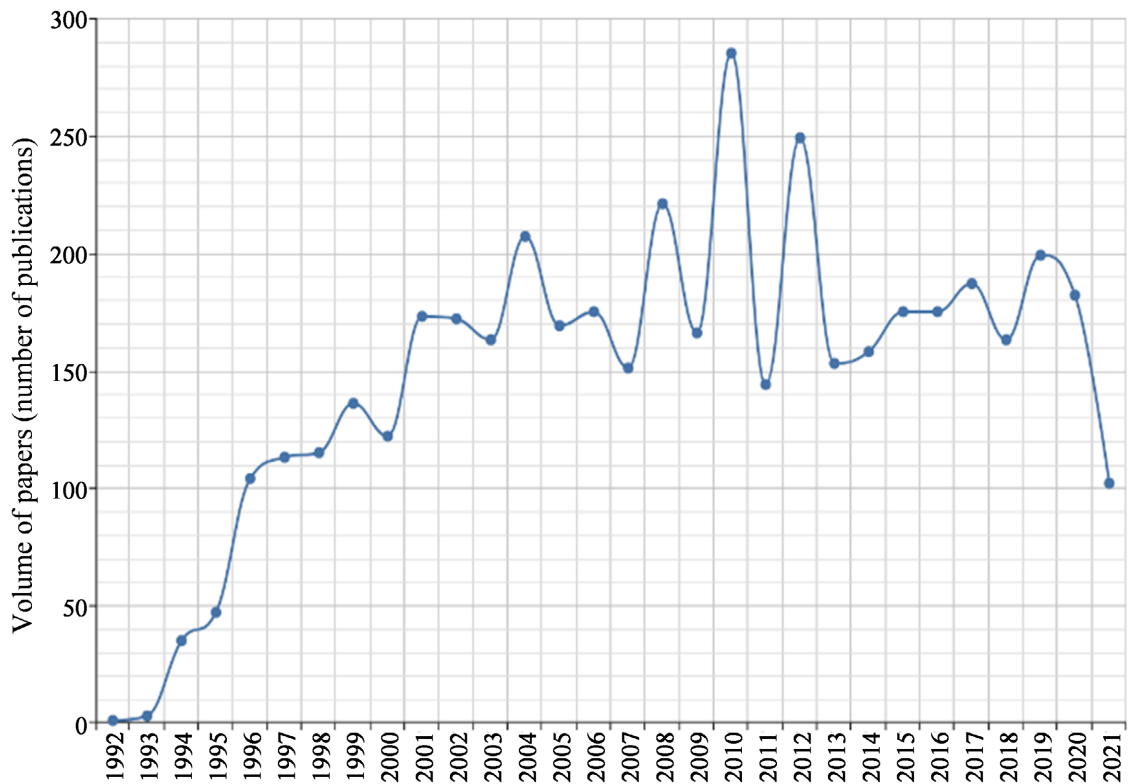


Figure 4. Research trend chart of the annual volume of zhusuan mental arithmetic-related publications.

culture of zhusuan.

3.2. The Present: Research on Zhusuan Culture and Education

This group of charts includes the research trend chart of the annual volume of zhusuan and mental arithmetic-related publications (**Figure 5**), research trend chart of the annual volume of zhusuan culture-related publications (**Figure 6**), research trend chart of the annual volume of zhusuan teaching-related publications (**Figure 7**) and research trend chart of the annual volume of zhusuan education-related publications (**Figure 8**). This group of charts is very interesting. They all show a sudden increase in the number of publications in 2012, suggesting that people were looking forward to the 2013 UNESCO resolution. And the expectations were warranted, since on December 4 of that year, Chinese zhusuan was officially listed in the UNESCO Representative List of the Intangible Cultural Heritage of Humanity. This group of research trends roughly echoes the development of zhusuan mentioned above, and more clearly predicts the future research orientation of zhusuan: Zhusuan will be integrated with culture and education. Transition from the past to the present: The research of zhusuan cultural pedagogy introduces the academic research of theories and methods, including relevant research on zhusuan teaching, cultural education, teaching and functions, and others.

3.3. The Future: Research on the Integration of Zhusuan across Separate Disciplines

The research trend chart of the annual volume of Chinese abacus English keyword-related publications (**Figure 9**) clearly shows a sharp increase in volume in 2018. Although the publication volume in 2018 was only five English papers, it has since showed steady development. Interestingly, papers on the subject have been published in English as early as 1950. The other research trend chart, that of the annual volume of zhusuan English keyword-related publications (**Figure 10**) shows the sudden appearance in 2002 of seven English papers, and thereafter only one English paper in each of the years of 2007, 2011, 2014, and 2017. From this chart, it may be seen that internationally the keyword “zhusuan” (in Chinese) is almost always translated as “Chinese abacus” rather than transliterated as “zhusuan”. “Chinese abacus” has become an internationally recognized phrase. The seven papers in **Figure 10** are from the “Proceedings of the Inaugural Ceremony of the World Association of Abacus and Mental Arithmetic”, whereas the World Association of Abacus and Mental Arithmetic was established on October 1, 2002. Since it was an international conference, the seven papers included in the conference proceedings are all in English, and most of them are cross-disciplinary collaborative research. Leaping from now to the future: Cross-professional and cross-field interdisciplinary integrative research.

Abacus course uses the abacus (Abacus) as a tool. According to the oral mnemonics, the beads are moved with fingers to complete mathematical calculations.

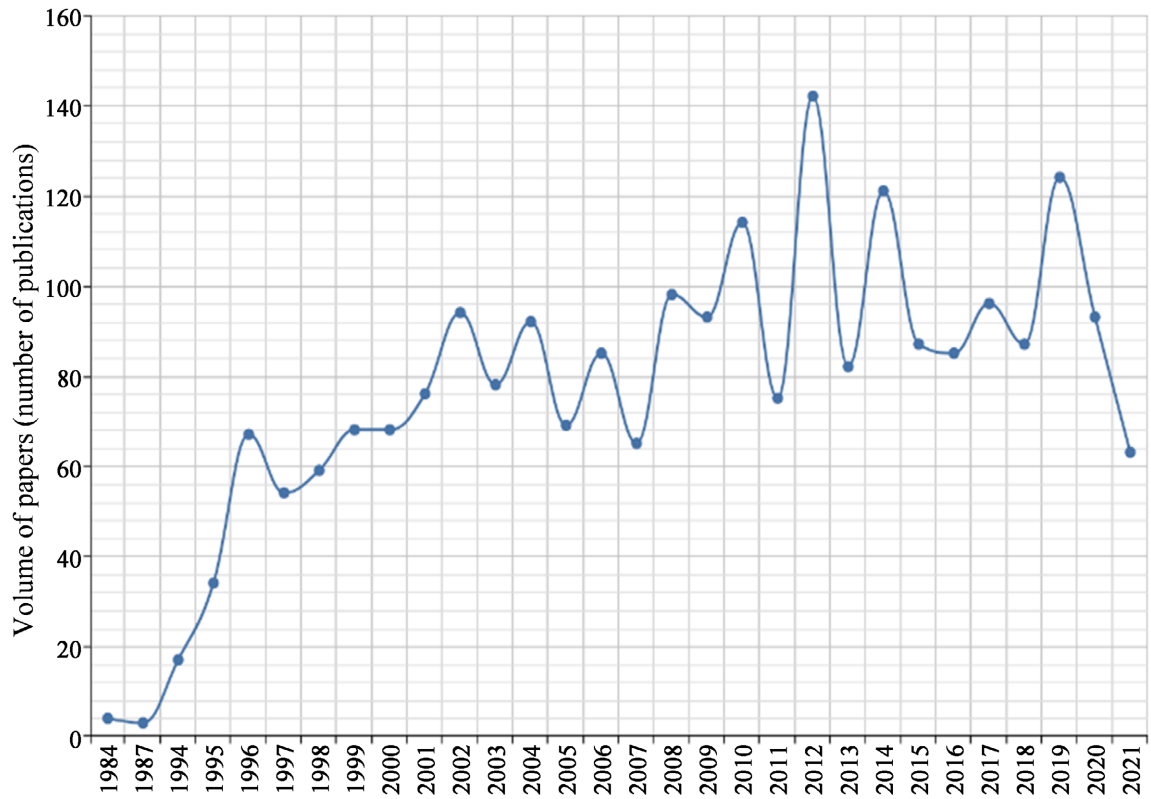


Figure 5. Research trend chart of the annual volume of zhusuan and mental arithmetic-related publications.

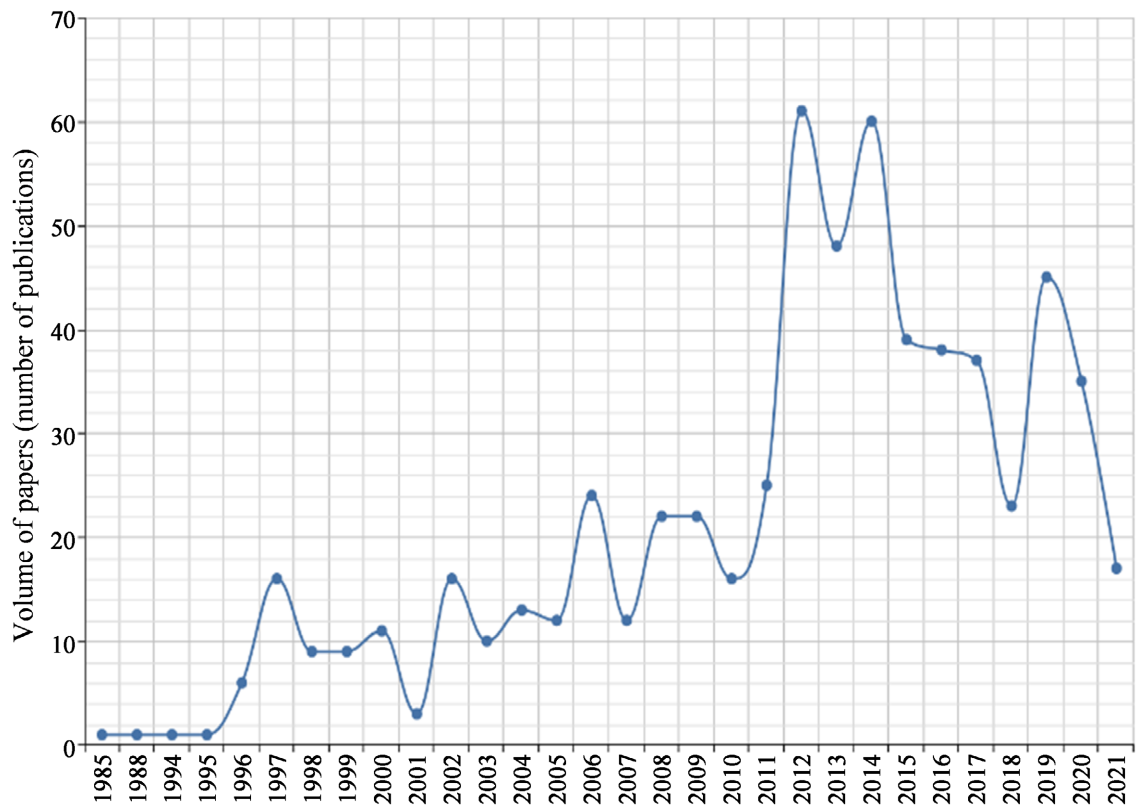


Figure 6. Research trend chart of the annual volume of zhusuan culture-related publications.

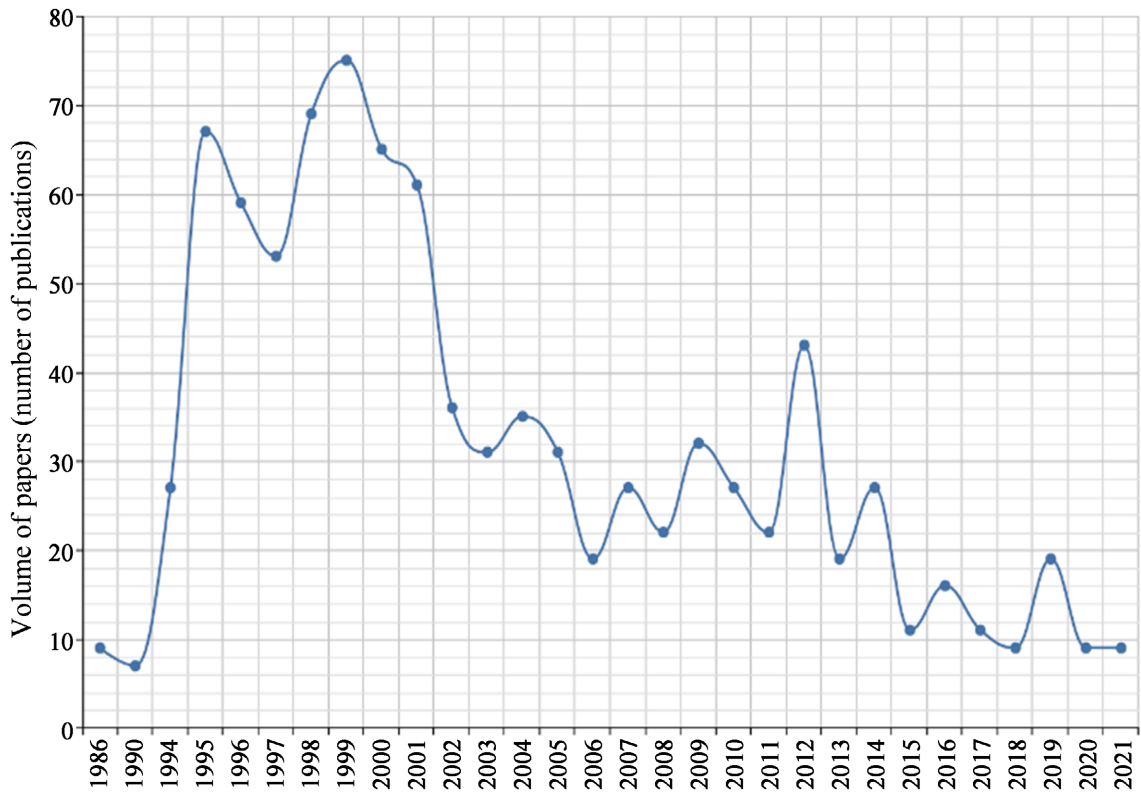


Figure 7. Research trend chart of the annual volume of zhushuan teaching-related publications.

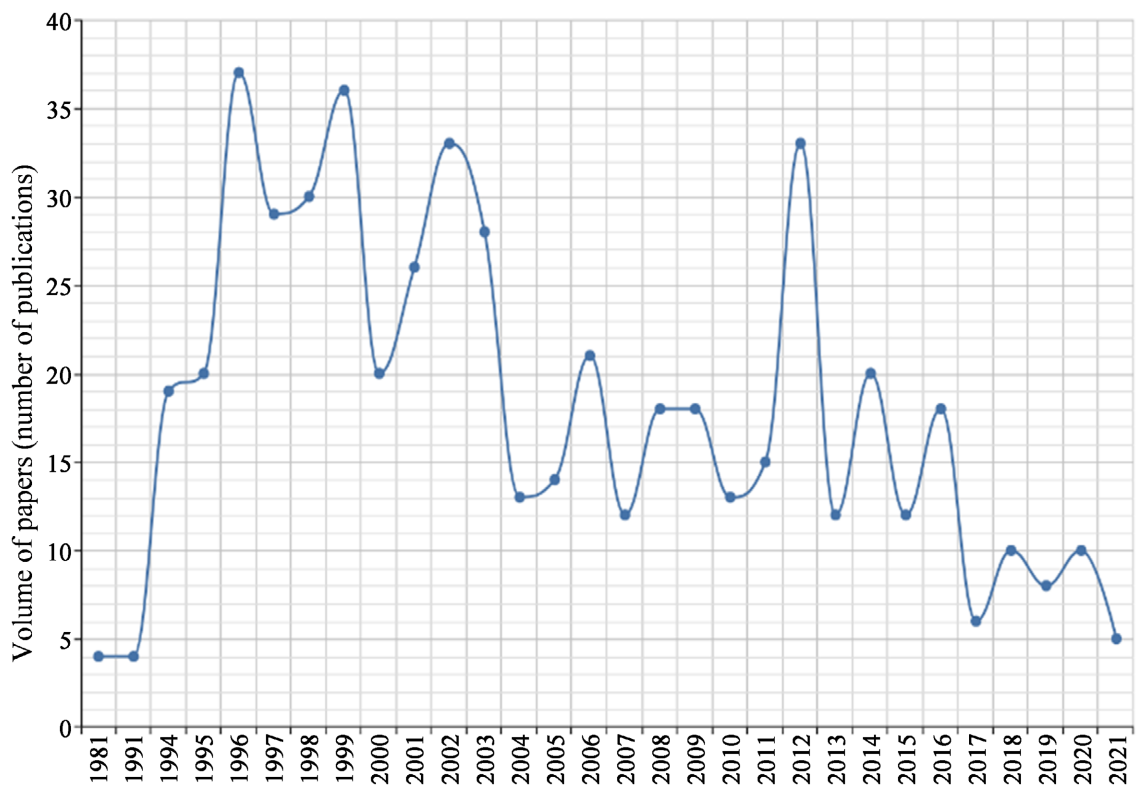


Figure 8. Research trend chart of the annual volume of zhushuan education-related publications.

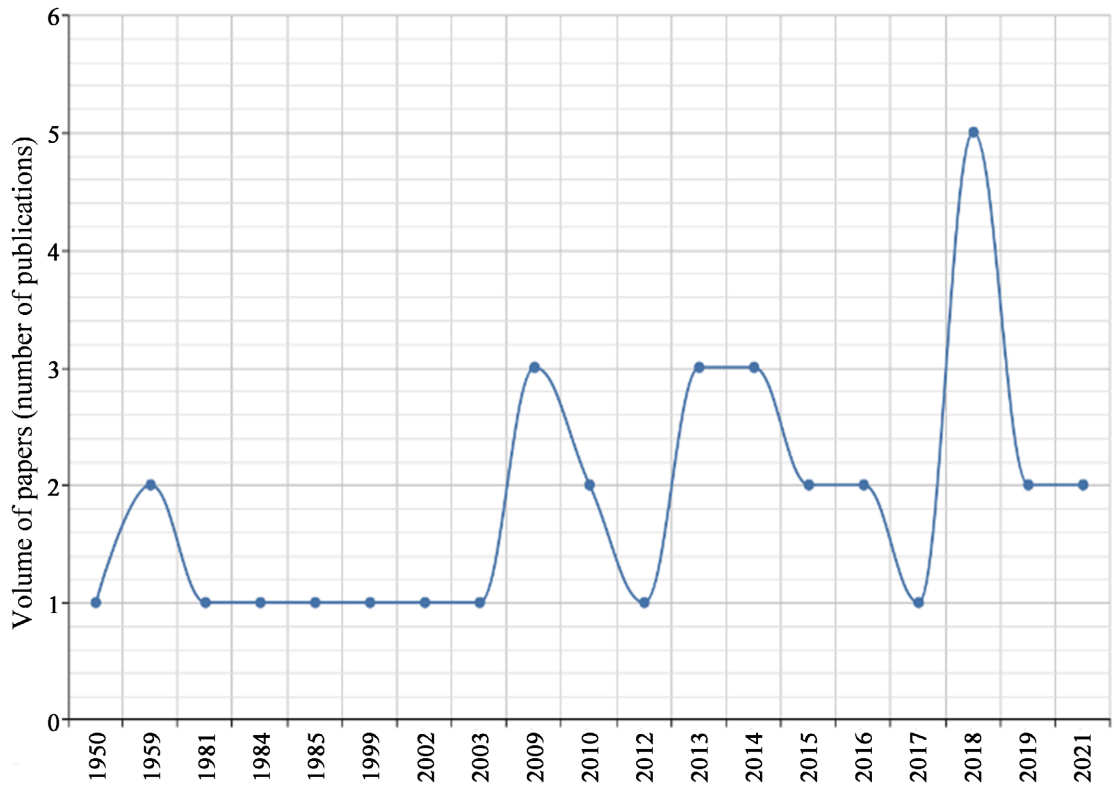


Figure 9. Research trend chart of the annual volume of Chinese abacus-related publications.

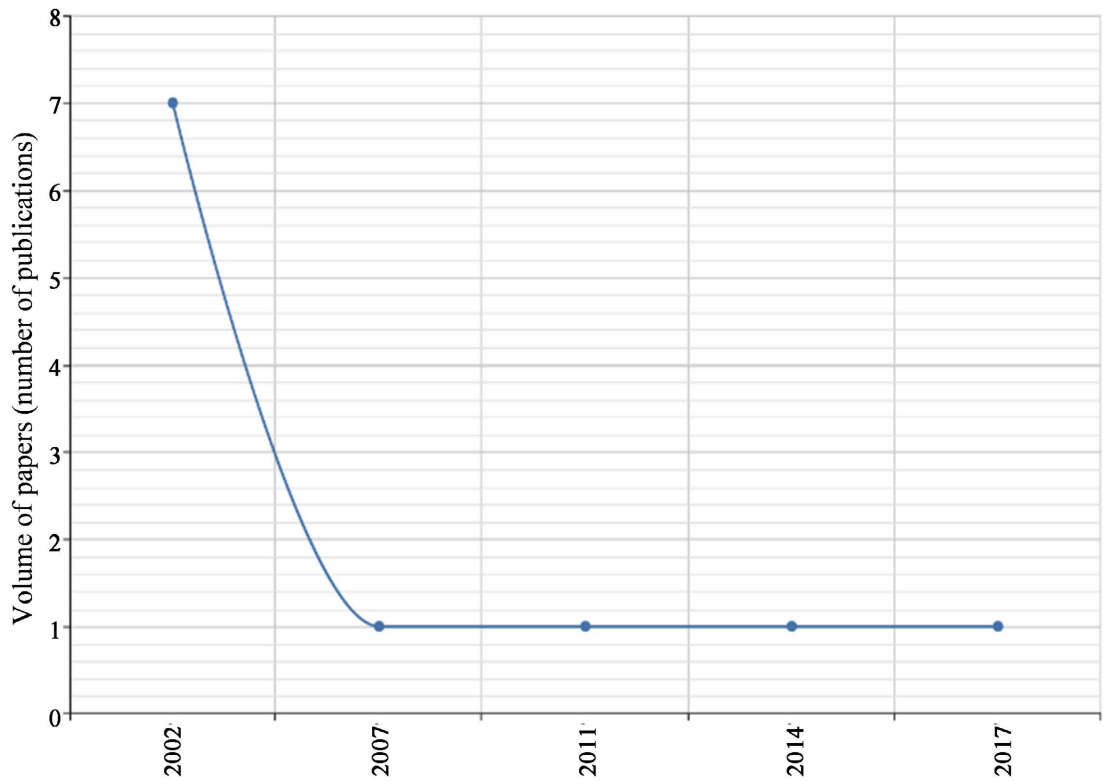


Figure 10. Research trend chart of the annual volume of zhusuan-related publications.

This calculation technology has been passed down from generation to generation and is a traditional calculation method with a long history. Abacus mental arithmetic training can improve children's concentration, memory and thinking skills. Abacus is a practical tool and a symbol of Chinese culture. It has multiple social and cultural functions and provides the world with another knowledge system.

4. Conclusion and Suggestions

In summary, although the research trend charts of the annual volume of publications cannot represent the level of publication quality, they still are able to convey the focus of most people's attention and the research orientation in certain years. Therefore, from the development of zhusuan and its research trends, and after cross-checking, we present the following three suggestions:

4.1. Taking Multiple Intelligences as the Theoretical Basis

At present, most countries have removed abacus courses from school mathematics courses. The present key issue in children's abacus education is that parents pay more attention to test results and competition results. Relatively little attention has been paid to the talent development of children's education. Therefore, researchers suggest that educators can develop children's potentials based on their multi-intelligence.

"Multiple Intelligence Theory" (MI) was proposed by Gardner in 1983. Gardner believes that human intelligence is not singular. MI includes: linguistic intelligence, logic-mathematical intelligence, musical intelligence, spatial intelligence, bodily-kinesthetic intelligence, intrapersonal intelligence, interpersonal intelligence and naturalist intelligence (Gardner, 1983). If human intelligence is not singular, but multiple, then education should be more diversified, including teaching methods, teaching strategies, assessment methods, and so on. The "Ninth Private Zhusuan Mental Zhusuan Arithmetic Teaching Innovation and Reform Exchange Seminar" was held in Suzhou, China, on September 22-24, 2021. During the seminar, Song Shibo shared his thoughts and made an appeal on the theme of "Innovation and Development in Zhusuan Mental Arithmetic Course Evaluation": "We need to change the traditional methods of curriculum evaluation and examine the comprehensive abilities of children across multiple dimensions," which echoes the theoretical foundations of MI theory.

We recommend the following for zhusuan mental arithmetic educators: The teaching and evaluation of abacus and mental arithmetic for schoolchildren ought not be limited to examination and competition. The main goal of learning is not to pursue advancement through examinations and win awards through competition. We understand that the zhusuan mental arithmetic educators at teaching sites are eager to show the parents the "results" of learning when they are forced to do everything required by parents. These "results" are sometimes only temporary. Most parents are not professional educators, and

more communication and exchange between teachers and parents are needed to “re-educate” parents: learning zhusuan mental arithmetic stimulates the development of children’s multiple potentials; and the primary goal of zhusuan mental arithmetic education is appropriate development. Therefore, the theoretical basis of MI can be used to develop students’ multiple potentials, regardless of age.

4.2. Taking Interdisciplinarity as the Research Method

In the past ten years, the researchers of physics and medicine have collaborated with educators across fields to focus on the impact of abacus education on children’s intellectual development and the prevention of dementia in the elderly.

Research conducted by the Interdisciplinary Research Laboratory of Zhejiang University in China found that children who have undergone long-term zhusuan mental arithmetic training have significant differences in their brain functional networks, mainly including the visual network, sensory motor network, and default network. Long-term zhusuan mental arithmetic training strengthens local information processing capabilities of these three networks, enhances computing power, digital cognitive processing, executive function/working memory, and brain plasticity (Zhang, Wang, Yao, Zhou, & Chen, 2021). This also supports the view that zhusuan mental arithmetic training can improve visual and spatial cognition (Wang et al., 2015). Zhusuan and cross-disciplinary applied research, such as “Mental Zhusuan Calculation Training Improves Cognitive Function in Elderly People” by the Chinese physicians Hu et al. (2017), and “Groups and Emotional Arousal Mediate Neural Synchrony and Perceived Ritual Efficacy” by Korean-American Philip and others (2018), all demonstrate that zhusuan mental arithmetic training is beneficial to brain activity.

All of the above are integrated, cross-disciplinary research of zhusuan and neuroscience. In the future, there will be cross-disciplinary research on the social practice of the elderly and blind children. At present, most researches on zhusuan-related interdisciplinary subjects are published in English and thus are not included in the CNKI database. Therefore, relevant research documents can only be tracked in English. However, this also highlights that the development of zhusuan from the Han cultural milieu to the cross-cultural sphere means it is no longer limited to Chinese society, and that it has received more attention and research from scientists around the world.

4.3. Taking Lifelong Education as an Educational Discipline

In 2019, the spread of COVID-19 was a great catastrophe to mankind. The education scene was severely impacted, and educational institutions, such as those teaching zhusuan mental arithmetic, encountered unprecedented difficulties. People must maintain social distancing, and can even be quarantined or isolated. When a person is in a completely separate space, the time spent without contact and disturbance is prolonged. Then, learning must be changed. In this sense, on-

line courses are imperative. Online learning has become an excellent way for people to not interrupt their education, so as not to waste time spent in isolation. Physical teaching and learning have been transformed into online teaching and learning; and it applies from young children to the elderly, from preschool education to lifelong education. With the epidemic temporarily in repose, hybrid online-offline teaching and learning has become a trend. There are a variety of educational courses in the online world that are available to any of the population who wants to learn; such courses can nearly meet the learning needs of all ages and groups. This suggests that this crisis is also a turning point. Suggestions: Zhusuan mental arithmetic educators can find an outlet in “Internet+” and hybrid online-offline teaching, which can expand the educational population to all groups through life-long education.

In its practical use, zhusuan expresses its instrumental applications in arithmetic and livelihood, and the value of medical care (Li, 1995). Research on the effectiveness of zhusuan mental arithmetic education has been confirmed by scientific experiments from the neural development of young children, the development of children’s potential, mathematical ability, and the prevention of Alzheimer’s disease in the elderly. Research shows that: The benefits of learning zhusuan mental arithmetic on the central nervous system do not differentiate between age, and are a form of lifelong learning that applies from childhood to old age.

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Conflicts of Interest

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

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