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# A Comparison of Australian and Chinese Primary School Intended Mathematics Curriculum

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**Abstract:** This paper provides a comparison of the intended curriculum between Australia and China and discusses the rationale to understand the differences and similarities of two systems. Documents review was used as the research method to analysis the common trends in reform in mathematics curricula, a rationale for mathematics curricula, objectives of mathematics curricula, key content of mathematics curricula, and the intended assessment. It found that although considerable differences exist in their rationales, there are still commonalities in terms of the objectives, content, suggestions for teaching, learning and assessment across the two systems. The authors recommend that to explore how the two systems put the intended curriculum into practice, there is a need to do more fieldwork.

**Keywords:** Australia, China, comparison, intended curriculum, assessment, mathematics, primary school

## 1. Introduction

Intended curriculum are defined as mathematics objectives and content in terms of what students are expected to study and what is expected to be assessed (Robitaille & Garden, 1996; Zhao, 2016). This paper presents a comparison of key differences and similarities between Australian and Chinese intended curriculum including educational policies, curriculum, and assessment documents, and discusses the rationale underlying their differences and similarities. Five aspects will be discussed in terms of common trends in reform, a rationale, objectives, key content, and intended assessment.

## 2. Common Trends in Reform in Mathematics Curricula

Since the late 1980s, considerable reform in mathematics curricula, including methods of teaching, learning, and assessing have occurred throughout the world. In this section, three common trends in reform in mathematics curricula in China and Australia are discussed.

### 2.1 Outcomes/standards-based education

It is widely acknowledged that outcomes/standards-based education has become the major trend in education throughout the Western world since the late 1980s (McGaw, 1995; Watt, 2000). In Australia, at the national level outcomes/standards-

based education has emerged as a significant influence on curricula. The *Mathematics Profiles* (ACC, 1994) and *Numeracy Benchmarks* (ACC, 2000) described commonly agreed outcomes and standards for mathematics education across Australia. At the state level, in NSW, *Mathematics K-6 Outcomes and Indicators* (BoS NSW, 1998) was structured according to the expected outcomes at the end of each stage of learning as a measure of effective teaching and learning. Schools are now encouraged to focus on and organize entire programs around clearly defined outcomes. Schools expect all students to demonstrate specified outcomes through each stage of learning (Zhao, 2016).

Similarly in China, there have been calls for urgent reform of traditional teaching, learning and assessment practices. The revised *Syllabus* (Chinese Ministry of Education, 1992) and the *Standards* (Chinese Ministry of Education, 2000) both advocate a 'reformation' in mathematics curriculum in China. The *Standards* indicate that Chinese mathematics curriculum should be transformed from an essentially content-based to an outcomes/standards-based educational practice (Zhao, 2016).

In terms of the rationale underlying the reforms, the two systems assume that increasing mathematics achievement is the key to developing knowledge and skills necessary to compete in a global economy. Based on the belief that the country's economic and social prosperity must rely on high levels of numeracy for

citizens within the workforce, the Australian goals for schooling have included numeracy as one of their national goals. Similarly, in China, economic development is regarded as closely linked with the development of science and technology, ultimately depending on mathematics learning. So, the achievement of mathematics outcomes is regarded as a key goal of educational reform both in China and Australia (Australian Ministerial Council on Education, Employment, Training and Youth Affairs, 1999; Chinese Ministry of Education, 2012).

### 2.2 A Constructivist approach to learning

Another major trend in contemporary mathematics education is based on the notion that students are actively involved in the construction of mathematics. Constructivist theory in mathematics learning suggests that learners personally negotiate meaning by creating different mental representations of mathematical knowledge (Zhao, 2016).

Australian mathematics documents such as the *National Statement* (AEC, 1990) and *Mathematics K-6* (BoS NSW, 2002) emphasize the need for learners to construct their own mathematical meanings and promote teacher - student interaction as the basis for quality mathematics learning. Similarly, in China the *Standards* (Chinese Ministry of Education, 2012) also adopts a constructivist view of learning, emphasizing not only the content but also the process of mathematics. The basic ideas contained in the *Standards* recognize that students construct their own mathematics learning.

### 2.3 Alternative assessment

Recognizing the limitations of paper-and-pen tests in assessing students' learning, educators are turning to the alternative, performance-based assessment supported by criterion-referenced standards. Such assessment helps educators gain a deeper understanding of students' learning and enables them to communicate evidence of that learning to their parents, employers, and the community at large (Zhao, 2016).

Both Chinese and Australian assessment policymakers recommend integrating assessment with teaching and learning and using a variety of strategies in assessing students' mathematics learning (Zhao, 2016).

## 3. A Rationale for Mathematics Curricula

It is widely acknowledged (AEC, 1990; Australian Ministerial Council on Education, Employment, Training and Youth Affairs, 1999; Chinese Ministry of Education, 1992, 2000; Australian National Council of Teachers of Mathematics, 2000) that mathematics as a

learning area is highly valued in primary schools all over the world. But there are distinct differences underpinning mathematics as a key learning area between countries. The following key questions are fundamental to all educational systems:

- What is mathematics?
- Why is it important to teach mathematics in primary school?
- How should mathematics be taught and learned?

The answers to these questions are multi-faceted and lay the foundation for explaining differences and similarities between mathematics curricula (Zhao, 2016).

### 3.1 The nature and role of mathematics

According to Australian documents, mathematics is a science of patterns and relationships (AEC, 1990, p. 4). It is a way of thinking characterized by processes such as exploring, manipulating, discovering, which provides a powerful, precise, and concise means of communication. At a fundamental level, it is concerned with practical applications in many branches of human activity (NSW DET, 1989, p. 2).

Australian curriculum developers have essentially adopted a constructivist view of mathematics and mathematics learning which recognizes that mathematics is a distinctive process of dealing with aspects of reality as learners construct their own knowledge (Zhao, 2016). In terms of the purpose of mathematics, the emphasis in the Australian documents is on the practical value of mathematics in fields of social science, medicine, economics, commerce, engineering, and arts, in which mathematics is perceived as a means of communication. The reason for this emphasis is expressed clearly in a recent document, *Numeracy, a Priority for All: Challenges for Australian Schools* (DETYA, 2000), in which numeracy is described:

Numeracy provides key enabling skills for individuals to participate successfully in schooling. Furthermore, numeracy equips students for life beyond school in providing access to further study or training, to personal pursuits, and to participation in the world of work and in the wider community (p. v).

This view suggests that an underlying rationale for Australian mathematics curricula is based on a philosophy of pragmatism and constructivism. According to Terwel (1999), although constructivism in education can be seen as a recent branch of the cognitive sciences, there is a direct link between constructivism

and pragmatism, both of which emphasize the active role students play in acquiring knowledge and the process of constructing knowledge.

In contrast, Chinese mathematics curriculum developers (Zhang et al., 1994) define mathematics “as a branch of science concerning the relationship of space and number in which reasoning is based on these relationships” (p. 4). As a science, mathematics consists of concepts, rules and laws characterized by abstraction and rigor.

Chinese curriculum developers (Chao, 1996) have traditionally adopted a more purist view of mathematics and mathematics learning. They recognize that the nature of mathematics is essentially a body of knowledge with a distinctive knowledge structure, which addresses the importance of concepts, rules, and laws of mathematics and understanding the structure of mathematics itself. The intended mathematics curriculum in China also emphasizes the importance of mathematics in terms of its relationship with further studies. According to the *Syllabus* (CME, 1992; 2000), mathematics is significant for further learning and is also the foundation for studying science and technology. Recognizing the abstract and rigorous characteristics of mathematics, Chinese mathematics educators also advocate that mathematics can be used as a useful tool in training students’ logical ability (Cao, 1996).

These two contrasting views of the Australian and Chinese curricula suggest that intended mathematics curricula are based on essentially different views about the nature and role of mathematics, reflecting different social and cultural traditions. This is supported by Leung (2001) who suggested that the traditional Chinese education system focuses only on the college entrance examination and the mathematics curriculum was designed for students to enter college, which stresses theoretical, rather than the practical knowledge. It is also acknowledged that the Chinese mathematics curriculum was influenced by the American ‘new mathematics movement’ of 1960s which emphasized ‘the structure of knowledge’ (Cao, 1996). In contrast, Australian mathematics curriculum developers have been more recently influenced by outcomes-based education which focuses more on teaching practical knowledge and problem-solving skills.

Current thinking suggests that there are distinctive features in mathematics curricula between East Asian and Western countries in terms of the nature of mathematics. In East Asian countries (take China as an example), mathematics knowledge is viewed more as a ‘product’ despite curriculum reform aimed at changing

this perception. In contrast, in Western countries (take Australia as an example), mathematics is perceived more as a ‘process’.

### 3.2 Key principles of teaching and learning

In accordance with the nature of mathematics, curriculum documents in both systems cover key principles and requirements for mathematics teaching and learning. Through the analysis of the current NSW Syllabus document *Math K-6* (BoS NSW, 2002), the principles of mathematics teaching and learning are described in terms of *students learning*:

- Students learn best when motivated
- Students learn mathematics through interacting
- Students learn mathematics through investigating
- Students learn mathematics through language
- Students learn mathematics as individuals but in the context of intellectual, physical, and social growth

In contrast, the Chinese *Syllabus* (CME, 1992) suggests three important principles as *requirements for teaching*: (pp. 4-8)

- Teaching is required to enhance students’ basic knowledge
- Teaching is required to develop students’ intelligence and ability
- Teaching is required to integrate mathematics with an education of ideology and morality

Besides these general principles, Chinese curriculum documents also include compulsory use of textbooks, which provide detailed suggestions for teaching and learning. It is recognized that (Zhao, 2016) the organization of textbooks implies that there are two principles underlying Chinese mathematics teaching:

- Mathematics teaching should stress the interrelationships and integration of mathematical knowledge
- Mathematics teaching should suit the students’ level of cognitive ability

According to Leung (2001) there are distinctive features about mathematics teaching between East Asian and Western countries in terms of the teachers’ role. In East Asian countries (take China as an example), the mathematics teacher is required to play a central role in the teaching process. The teacher is assumed as an expert in mathematics and mathematics knowledge is transferred from teacher to students. In essence this is a transmission model. In contrast, in Western countries (take Australia as an example) the role of the teacher is more of a facilitator of learning, helping students to

learn. However, the transmission role of the teacher is still apparent in many Australian classrooms.

### 3.3 Common features

From the documents review (Zhao, 2016), it is found that there are common characteristics shared by both systems about the nature of mathematics and the purpose of mathematics learning. Both countries define mathematics as ‘a science of relationships,’ and recognize that mathematics is pursued both for a variety of practical purposes and for its intrinsic interest. There is a common view that mathematics is:

- the study and mastery of basic knowledge and skills
- a foundation for other subjects
- important for mathematical thinking

There are two indicators that highlight the status of mathematics in both systems. First, developing students’ basic mathematics knowledge and skills, or ‘numeracy’ is represented as one of the most important goals of education both in Chinese and Australian primary schools. Second, in China, mathematics and the Chinese language are the only two subjects requiring formal assessment at the end of primary school. Similarly, literacy and numeracy are the only two areas that require standardized assessment in NSW (i.e., Basic Skills Testing Program at Years 3 and 5 in NSW primary schools and in other Australian states).

The rationales underlying Chinese and Australian mathematics curricula may be built on different philosophical, social, and cultural bases (Zhao, 2016). In the following sections further discussion of the relationship between these rationales and other aspects of mathematics curricula are presented.

### 4 Objectives of Mathematics Curricula

According to TIMSS studies (Mullis et al., 2000), the nature and extent of mathematics objectives to be attained are essential to policy makers and curriculum specialists in all countries. One concern of international studies is to examine the curriculum objectives of the education system and how it is organized to attain those objectives. In comparing Chinese and Australian documents, it is found that the specific objectives or outcomes of mathematics curricula vary considerably in quantity, depth, and order but common objectives exist across the two systems.

The Chinese syllabus documents (CME, 1992; CME, 2000) describe the objectives of mathematics teaching in primary schools in three ways:

- to promote students’ understanding and mastery of fundamental knowledge of numerical relationships and geometrical patterns
- to develop students’ ability to compute the four operations of whole numbers, decimals and fractions, develop logical thinking and spatial sense, acquire knowledge to solve simple practical problems
- to cultivate in students an ideological and moral education

These objectives ordered by importance, indicate that cognitive aspects of learning are a priority for Chinese current mathematics curriculum. It focuses on fundamental knowledge and skills and students’ logical thinking. It also recognizes the social domain of mathematics as critical, using mathematics for the purpose of developing ideological and moral education.

In comparison, the objectives of mathematics education in Australian documents (AEC, 1990, BoS NSW, 2002) reflect a concern for students developing positive attitudes towards mathematics, as well as the development of knowledge and skills, and information technology processes. For example, *Mathematics K-6 Outcomes and Indicators* (BoS NSW, 1998) also divides mathematics objectives into three aspects:

- To appreciate mathematics as an essential and relevant part of life
- Develop students’ ability to work mathematically
- Develop students’ knowledge, skills and understandings in Space, Measurement and Number

Unlike the Chinese documents, the top priority in Australian documents is on the process of learning and application, and no moral-political objectives are evident in the Australian mathematics curriculum. Another difference (mentioned in *Mathematics K-6*) is ‘developing in students’ appropriate language for the effective communication of mathematics of technology, including calculators and computers.’ This is addressed in the Australian mathematics curriculum, while it is not mentioned in the current Chinese mathematics curriculum.

The above discussion has indicated that considerable differences exist in terms of the specific content and priorities in mathematics curriculum between Australia and China. Leung (2001) suggested that different views on the nature of mathematics may

contribute to the different emphases in mathematics curricula between East Asian countries (including China) and Western countries (including Australia). Zhao (2016) suggested that Chinese curriculum developers generally adopt a purest view of mathematics and maintain that learning the content of mathematics is the most important objective for mathematics curricula. In contrast, Australian curriculum developers adopt a constructivist view of mathematics and assert that experiencing the process of mathematics through practical activities is the most important objective for mathematics curricula.

As well as these differing views of the nature of mathematics, the formulation of objectives is also influenced by other factors such as general goals of education, and the social, cultural, economic and political background (Niss, 1996). According to Price (1992), moral-political objectives included in mathematics curriculum in China were determined largely by the Chinese social and political situation where moral-political objectives are set as a general educational goal and conveyed by all subjects of the school curricula and by out-of-class activities. Educational authorities in China base this practice on the simplistic belief that student learning can be 'forced' to conform with teaching and that student behavior will then conform to such learning. The intended curriculum then acts as a powerful influence on student values and beliefs.

There are also common characteristics shared by both systems. Both systems divide curriculum objectives into cognitive and non-cognitive domains. In terms of the cognitive domain, both systems:

- (i) recognize that mathematics teaching and learning should incorporate key aspects of knowledge, comprehension, application, analysis, synthesis, and evaluation
- (ii) stress the importance, in varying degrees, of developing students' basic mathematics knowledge and skills in the areas of number, space and measurement
- (iii) recognize the importance of problem solving in mathematics learning

By including mathematical processes in the curriculum objectives, the newly published *Chinese Mathematics Standards* (CME, 2000) adopts, to some extent, a constructivist view of mathematics teaching and learning addressing the link between mathematics

and students' daily life and emphasizing the importance of participation and interests in mathematical activities.

In terms of the affective domain, both systems:

- (i) recognize the importance of students' motivation to learn mathematics in the primary school
- (ii) recommend that to promote students' positive attitudes towards mathematics, mathematics teaching and learning should relate to students' daily lives, to other mathematical topics and to other curriculum areas

To exemplify the above similarities and differences, specific mathematical content areas have been selected and these are analyzed in the following section.

## 5. Key Content of Mathematics Curricula

### 5.1 Number

Through documents review, it is found that common aspects of Number in the NSW and Chinese mathematics curriculum include numeration, basic number facts and the four operations. However, by closely comparing the content, considerable differences are found in each sub-strand of Number. These are discussed as follows.

#### 5.1.1 Numeration

In the sub-strand of numeration, considerable differences exist between the two systems. The Chinese curriculum not only covers more aspects of numeration but also it is more abstract. For example, the development of the structure of the decimal system and the knowledge of place value are regarded as a foundation to an understanding of mathematical concepts and processes in the Chinese curriculum. In contrast, the Australian curriculum developers pay more attention to the use of concrete materials in order for students to understand numeration. The differences within numeration reflect the different rationales underpinning mathematics curricula in the two systems. As mentioned earlier in this chapter, Chinese curriculum developers address the understanding of mathematical structure itself as top priority. While the NSW syllabus also adheres to this, it is more focused on achievement of outcomes through mathematical activities.

#### 5.1.2 The four arithmetic operations

In the sub-strand of the four operations, there are a number of differences between the two curricula. On the one hand, the Chinese curriculum not only covers more difficult calculations in terms of numerical difficulty, but also emphasizes underlying structure, showing the

relationship between different operations and laws. In contrast, the NSW curriculum proposes less complicated operations and students are encouraged to use calculators in dealing with multi-digit calculations. These differences are rooted in the main objectives of the two systems. The four operations are the foundation of mathematics in China, so one of the most important mathematics objectives is to acquire working knowledge and skills in dealing with the four operations. This focuses on applying standard algorithmic procedures to answer pencil-and-paper number questions and developing mental computation ability. Currently the Chinese curriculum encourages the utilization of standard written algorithms and mental computation, while the calculator is not allowed.

#### 5.1.3 The use of calculators

To examine the relative advantages and disadvantages of the Number content chosen by the two systems, it is essential to consider the role of calculators. According to Groves (1996, 1997) and Hembree and Dessart (1986, 1992), several studies recognize the value of calculators in early schooling. American curriculum documents (National Council of Teachers of Mathematics, 1989, 1991, 1995, 2000) also advocate the use of calculators in school mathematics. Building on these recommendations, the Chinese curriculum has introduced calculators in school mathematics. Following the trend of encouraging the use of calculators in mathematics education, the *Standards* advocates that calculator can be used in mathematics classrooms in Chinese primary schools in the future.

#### 5.1.4 Fractions and decimals

There are also some differences within the sub-strands of fractions and decimals. The Chinese curriculum not only contains more abstract concepts than required in the NSW syllabus (e.g., the meaning of multiplication and division of fractions is included in Chinese curriculum but not in NSW curriculum) but also includes more difficult computing of the four operations (e.g., mixed computing of four operations of fractions and decimals is included in Chinese curriculum but not in NSW curriculum).

In contrast, the NSW curriculum not only addresses the use of concrete materials to develop mathematical concepts but also pays more attention to the involvement of students in the process of learning. Again, the differences are also rooted in the different rationales and objectives of the two systems. It is widely acknowledged (e.g., Schmidt et al., 1997) that concepts of fractions and decimals and their operations are the most difficult topics for primary school students. The

major difficulties are problems with symbolic representations and applying whole number ideas to fractions. The work of Moss and Case (1999) recommend that to conceive of fractions as objects embodied in numerical relationships, students are required to engage in problems, tasks, and explorations to promote rich conceptual understanding. Building on these recommendations, it is suggested that the Australian curriculum may need to include more topics in the sub-strands of fractions and decimals, especially the relationships between fraction and other sub-strands. The Chinese curriculum may need to pay more attention to students' understanding of the fraction and decimal concepts instead of focusing on the four operations with fractions and decimals.

#### 5.1.5 Money

In the sub-strand of money, the two systems have both focused on the introduction of their own currency systems. In NSW, the sub-strand includes sorting and classifying coins, recognizing the face values of notes and coins, and trading. In contrast, the Chinese syllabus only requires students to know the units of Chinese currency and simple computing. It is clear that two major differences exist. The first difference is in the categorization of the strand. Money was under the sub-strand of measurement in the Chinese curriculum, while it is included as a sub-strand of number in the NSW curriculum. Another difference is that NSW links the learning of money with students' daily life (e.g., a shop). The major reason for these differences is the logical consideration versus the practical consideration of curriculum content. By focusing on the units of currency, Chinese curriculum intends to build students' logical relationships between number and measurement. In contrast, the NSW syllabus pays more attention to the application of money in practice and using concrete materials to help students' learning of number.

To sum up, in the Number strand, both Chinese and NSW documents emphasize the understanding of basic concepts of numeration, fractions, decimals and mastering the four operations. However, it appears that the Chinese intended curriculum pays more attention to the systematic learning of concepts, laws, and relationships, while the Australian documents address the processes and skills in number learning. The Chinese documents also contain more advanced content in the number strand. These differences indicate that Chinese mathematics curriculum developers emphasize more theoretical aspects of number. In contrast, NSW mathematics curriculum developers are concerned more with practical applications of number.



## 5.2 Measurement

Table 1 (See appendix 1) summarizes the major differences in the Measurement strand of the NSW and Chinese primary school mathematics curricula.

A comparison of the content in Table 1 shows that there are considerable similarities between the two systems. It is obvious that units of length, mass, time, area, and volume are major topics that represent the basic concepts of measurement emphasized by the two countries. However, several differences can be found. The NSW curriculum provides not only more detailed information about the development of measurement concepts, but also contains one more sub-strand (temperature) compared to the Chinese curriculum. Taking the sub-strand of area as an example, the description of the content is quite different. The difference suggests that NSW curriculum is focused on involving students in the process of measurement activities, while the Chinese curriculum addresses the formula for the calculation of the area of different geometric figures.

Two major reasons can be used to explain these differences. The first reason is that the Chinese curriculum stresses the relationships between measurement and other strands, and measurement concepts such as area and volume are included in other strands. According to Chinese curriculum developers (Cao, 1996), number and geometry are the bases of measurement learning, so measurement content is integrated with number and geometry. For example, because area and volume of geometric figures are related, the units of area and volume are integrated within geometry. In contrast, the NSW curriculum focuses more on the process of understanding the concepts separately and the calculation of units. Taking volume as an example, the NSW syllabus contains more information about how to calculate volume through the process of observation, comparison, and utilization of informal and formal units.

The second reason is the logical versus practical approach of curriculum content. As discussed early in this chapter, Chinese curriculum puts more emphasis on the logical order of knowledge, while NSW curriculum focuses on the application of knowledge in practice. Taking the topic of temperature as an example, according to Chinese curriculum developers (Lu, 1998), to fully understand temperature requires to firstly understand the concept of negative numbers, which is normally learned in junior high school. In NSW, the syllabus shows temperature as an important measurement topic and encourages students to explore

underlying informal aspects. However, the new NSW syllabus (BoS NSW, 2002) eliminates temperature from the syllabus.

Another difference is the topic of composite units, which is included in the Chinese curriculum but not in the NSW curriculum (e.g., in the Chinese *Syllabus*, in the sub-strand of volume, the concepts of single units and composite units are introduced). According to research on measurement (McClain, Cobb, Gravemeijer & Estes, 1999), the idea of composite units is closely linked to early measurement sense. Based on these studies, it is suggested that the NSW curriculum may need to emphasize composite units in its measurement strand, while the Chinese curriculum needs to pay more attention to the process of learning measurement through informal exploration.

In summary, the NSW curriculum stresses the practical use of measurement, while the Chinese curriculum addresses the relationships between measurement and other strands.

## 5.3 Space and Geometry

The major differences in content between Space and Geometry in the NSW and Chinese primary school mathematics curricula can be summarized in table 2 (See Appendix 2).

From the above summary, it is shown that Chinese curriculum includes less content in Space and Geometry than that of NSW. For example, the NSW Space strand comprises broad ideas and experiences related to interpreting diagrammatic representations, and position and orientation. This suggests that more emphasis is placed on practical representations of geometry in the NSW curriculum.

Besides obvious differences in content, the two systems share considerable commonalities including most of the three-dimensional (3D) and two-dimensional (2D) content. This indicates that developing basic knowledge of 2D and 3D shapes related to space and geometric figures is considered important in both countries.

In terms of emphasis, further differences are found. It is clear that the NSW curriculum puts more attention on the role of visualization and imagination in the early stages of the Space and Geometry, while the Chinese curriculum pays more attention to the relationships between Space and Geometry with other strands.

In summary, in the space and measurement strands, the NSW curriculum focuses on development of spatial sense, while the Chinese curriculum focuses more on computation and relationships between space and measurement.

#### 5.4 Other content

In addition to the three major strands, working mathematically, statistics, ratio and proportion, and algebra strands are contained in both curricula. There are quite a few differences in content which are described as follows.

##### 5.4.1 Problem solving

In terms of problem solving, NSW curriculum focuses on the processes of working mathematically (including questioning, problem solving, communicating, verifying, reflecting, and using technology). It is suggested that using mathematical knowledge, practical skills, and communication, and experiencing the process of investigation be treated as problem-solving processes in NSW curriculum. In contrast, the Chinese syllabus contains a series of word problems ranging from one-step to four-step word problems. The major purpose of word problems is to train students' thinking logically, so most problems are found to be artificial ones which have little to do with real life practice.

##### 5.4.2 Data and statistics

In terms of statistics, the 1989 NSW syllabus integrates data and statistics into the Space strand. By categorizing it with Space, it includes pictorial representation of groups of objects, column graphs and picture graphs. The NSW curriculum addresses the importance of graphing skills within statistics. However, in the new 2002 NSW Syllabus, data is arranged as a separate strand. In contrast, the Chinese curriculum addresses key statistical concepts (e.g., mean) and systematic learning of statistics (e.g., from data sorting to interpreting the data) across each stage of learning.

##### 5.4.3 Ratio and Proportion

There are considerable differences between the two curricula in the areas of ratio and proportion. The NSW curriculum includes some basic ideas such as number patterns and percentages closely related to the concepts of ratio and proportion. However, the Chinese syllabus introduces not only the concepts of ratio and proportion, but also requires students to solve proportional problems. According to the TIMSS study (Mullis et al., 2000), most countries report that ratio and proportion are learned in high schools. The Chinese mathematics curriculum is much more advanced and abstract, compared to other countries, in terms of ratio and proportion content.

##### 5.4.4 Algebra

In the area of algebra, the 1989 NSW syllabus mentions number patterns related to algebra but does

not include any specific indications. However, the new 2002 syllabus includes strand on patterns and algebra. On the other hand, the Chinese document pays great attention to introducing algebra. In the Chinese curriculum, as early as Year 1, basic ideas of algebra are integrated within the Number strand. In Year 3, the use of letters to represent numbers is introduced. Accompanied by the teaching of computation, laws of addition, multiplication, calculation of area and volume of geometric figures as well as the symbols of the alphabet are used to represent computational laws and formulas. After students have experienced the advantage of using symbols to represent number patterns, the formal use of symbols to represent number is introduced in Year 4. Students are encouraged to understand the meaning and function of using letters of the alphabet to represent numbers. In Year 5, simple equations are introduced. According to the TIMSS data (Mullis et al., 2000) most countries do not include algebraic equations in primary school curricula, although some ideas of algebra are introduced. By including algebra in primary schools, it is again clear that the Chinese mathematics curriculum is more abstract and much more advanced in content than the NSW curriculum.

To sum up, the comparison of curricula shows that there are several key topics common to Number, Measurement and Space across the two systems. However, Australian curriculum developers pay more attention to achieving a balance of content across the three strands, Chinese curriculum developers put more emphasis on the Number strand. The Australian curriculum focuses more on developing processes and practical utilization of mathematical knowledge and skills, while the Chinese curriculum focuses more on relationships between different content and the structure of mathematical knowledge. The Australian curriculum adopts a constructivist approach to mathematics learning, but the Chinese curriculum traditionally has adopted a purist approach to mathematics and a transmission model of learning.

#### 6. Intended Assessment

In terms of assessment, curriculum documents in both systems include suggestions for assessment at system level which are viewed as intended assessment. In this section, similarities and differences in the rationale underpinning intended assessment in both countries are discussed.

##### 6.1 Principles of assessment

The Australian *National Statement* (AEC, 1990) stipulated two general principles about assessment:

- Assessment should reflect all the goals of the school mathematics curriculum
- Assessment should be demonstrably fair, valid, and reliable

In comparison, in China, the *Syllabus* (Chinese Ministry of Education, 2012) asserts that:

- Mathematics assessment should be based on the teaching objectives and basic requirements of the syllabus
- Mathematics assessment should not only assess students' understanding and mastery of basic mathematical knowledge, but also students' mathematical ability

Analyzing the above principles, both Chinese and Australian assessment policymakers put the alignment of assessment of syllabus outcomes as an underlying principle for mathematics assessment.

### 6.2 The nature and purpose of assessment

The Australian framework for curriculum (the *National Statement*) outlines the nature of assessment as an integral part of the learning process. The major purpose of assessment is the improvement of learning. *Mathematics K-6* (NSW DET, 1989) describes assessment as "the process of gathering evidence of and making judgement about students' needs, strengths, abilities and achievements" (p. 42). In understanding a rationale for assessment, *Assessment K-6* (NSW, DET, 1996) asserts that assessment should lead to improvement in student learning because information gained through assessment can provide feedback to students and teachers, which leads to more effective programs catering for the needs of individuals. According to *Assessment K-6* (p.2), assessment is used to:

- Gather information about students' development and achievement
- Facilitate the planning of further learning experiences
- Provide teachers with a starting point
- Help evaluate the effectiveness of the teaching program
- Highlight the need to target particular groups or individuals

In contrast, according to Chinese curriculum documents (CME, 1992) mathematics assessment should be based on the teaching objectives and basic requirements of the *Syllabus*. It requires not only

assessment of students' understanding and mastery of basic mathematics knowledge, but also students' mathematical ability. It is also recommended that the teacher should enhance students' learning capabilities by improving the methods of assessment. The *Standards* insists that the purpose of assessment is to enhance students' all-round (including moral, intelligent and physical education) development. The *Syllabus* also asserts that by improving methods of assessment, students are encouraged to put more effort into studying. This suggests that more rigorous assessment, using a variety of measures, encourages students to study harder.

Assessment in both systems is closely linked with teaching and learning, and the major purpose of assessment is to enhance students' learning. However considerable differences exist in terms of the rationale for assessment. Australian documents focus on feedback to teachers about their teaching methods from assessment, while Chinese documents focus more on using assessment feedback to promote students' self-motivation to improve.

### 6.3 Suggested strategies for assessment

Mathematics curricula in both China and Australia describe appropriate assessment strategies. For example, considering the fairness, validity and reliability of assessment, the Australian *National Statement* recommends that more developmental work is needed on useful, practical and fair assessment strategies. Recognizing that students demonstrate evidence of their learning through speaking, writing, drawing and engaging in other activities, the NSW *Mathematics K-6* encourages a variety of assessment strategies including pen-and-paper tests, observation, listing, structured interviews, student-teacher discussions, student explanation and demonstration, samples of student work and practical investigations.

Similarly, the Chinese curriculum pays attention to assessment strategies. The Chinese intended assessment suggests that assessment takes the form of open or closed book examinations, oral tests or a practical test using concrete manipulations. The reporting of students' achievement is made by a quantitative marking system using percentages, or a grading system or teachers' comments. The Chinese *Syllabus* suggests that although the primary method of mathematics assessment is paper-and-pen examination, oral examination and practical tasks are also encouraged. Besides the end-of-term examination, the *Syllabus* argues that more attention should be put on daily classroom teaching and homework in order to have a

better understanding of students' performance. Teachers are encouraged to use these sorts of information to improve teaching and students' learning performance. The Chinese *Standards* suggests that the methods of assessment should have a variety of approaches such as paper-pen examination, thematic activities, written essays, group activities, self-assessment and daily observations so that the teacher can synthesize these data to make valid judgements in assessment.

Document analyses of intended assessment indicate that a variety of strategies for mathematics assessment are recommended by both systems. However Chinese curricula emphasize more formal paper-and-pen examinations whereas NSW emphasizes a broader range of assessment strategies.

#### 6.4 Other assessment issues

The Chinese curriculum guideline, the *Syllabus*, divides assessment into summative assessment and formative assessment. In terms of summative assessment, the *Syllabus* requires that summative end-of-semester examinations, end-of-school-year examinations and a final examination on graduation from primary school should be used to assess the students' level of achievement. It also divides assessment into formal and informal assessment and recommends that students should take a formal assessment once every semester and informal assessments during teaching and learning activities.

Unlike Chinese documents, in Australia, both at national and state level, there are several documents such as *Mathematics K-6 Outcomes and Indicators*, *Mathematics Assessment K-6 and Strategies for Assessment* which assist teachers, schools and systems with the complex process of assessment and provide common guidelines and examples. Thus, the intention in Australia is to make models of appropriate assessment practice explicit for teachers.

#### 7. Conclusion

In summary, this paper has discussed five important aspects of the *intended* mathematics curriculum both in China and in Australia. Although considerable differences exist in their rationales, there are still commonalities in terms of their objectives, content, suggestions for teaching, learning and assessment across the two systems. When putting the reform agenda of the two systems into the context of world educational reform, it is clear that they each follow a world trend in educational reform. They each advocate (*intend*) an outcomes/standards-based

rationale, adopt a constructivist approach to teaching and learning, and encourage integrating assessment practices with teaching and learning. To explore how the two systems put the intended curriculum and assessment into practice, there is a need to do more fieldwork (Zhao, 2016).

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**Appendix 1: Table 1 Major differences in Measurement content**

Content	NSW	China
Length	<ul style="list-style-type: none"> <li>Ordering lengths and distances</li> <li>Informal units of length</li> <li>Investigating the need for units</li> </ul>	<ul style="list-style-type: none"> <li>Recognize formal units of length and computation</li> </ul>
Area	<ul style="list-style-type: none"> <li>Awareness of the attribute of area</li> <li>Measurement with informal area units</li> <li>Comparison and ordering of areas</li> <li>Awareness of the need for a standard unit</li> <li>Measuring land area</li> </ul>	<ul style="list-style-type: none"> <li>The meaning of area</li> <li>The area of rectangle, parallelogram, triangle, and trapezoid</li> <li>The surface area of cuboid, cube, cylinder</li> </ul>
Volume	<ul style="list-style-type: none"> <li>Ordering containers according to capacity</li> <li>Measurement of volume using informal units</li> <li>Displacement as a means of ordering volume</li> <li>Investigating relationships between volume, capacity and mass.</li> </ul>	<ul style="list-style-type: none"> <li>Single units and composite units</li> <li>The meaning of volume</li> <li>Volume of cuboid, cube, cylinder, and cone</li> </ul>
Mass	<ul style="list-style-type: none"> <li>Understanding balance</li> <li>Measuring devices</li> <li>Formal units</li> </ul>	<ul style="list-style-type: none"> <li>Simple computing of formal units of mass.</li> </ul>
Time	<ul style="list-style-type: none"> <li>Passage of time using informal units</li> <li>Use of a stopwatch</li> <li>Formal units of time and calendar</li> </ul>	<ul style="list-style-type: none"> <li>Measuring time</li> <li>Chinese year: leap year, non-leap year</li> </ul>
Temperature	<ul style="list-style-type: none"> <li>Awareness of the attribute of temperature</li> <li>Comparison of two temperatures</li> <li>Temperature measurement with informal units</li> <li>Awareness of the need for a standard unit</li> <li>The degree Celsius as a formal unit</li> <li>The use of various thermometers and temperature scales.</li> </ul>	Not included in Chinese curriculum

**Appendix 2: Table 2 Major differences in Space and Geometry content**

Content	NSW	China
Space 3D	<ul style="list-style-type: none"> <li>Patterns with 3D objects</li> <li>Investigating the properties of prisms, cylinder, pyramids, cones and spheres</li> <li>Investigating topology</li> </ul>	<ul style="list-style-type: none"> <li>The properties of cuboid, cube, cylinder, cone</li> <li>Basic understanding of the sphere, radius and diameter of the sphere</li> </ul>
Space 2D	<ul style="list-style-type: none"> <li>Relationship of 3D objects to 2D shapes</li> <li>Recognizing line symmetry</li> <li>Investigating symmetry in patterns</li> <li>Investigating topology</li> <li>Investigating shape and pattern</li> <li>Investigating tangrams and puzzles</li> <li>Investigating transformations of shapes</li> <li>Investigating the properties of polygons</li> <li>Investigating patterns of lines</li> <li>Investigating shadows and perspective</li> <li>Investigating turning symmetry</li> <li>Patterns and tessellation</li> </ul>	<ul style="list-style-type: none"> <li>Basic knowledge of straight line, line segment, parallel lines, project line</li> <li>Right angle, acute angle, obtuse angle, straight angle and cycle angle</li> <li>The properties of square, rectangle, parallelogram, and trapezoid</li> <li>Combination of figures</li> <li>The circle; Ratio of the circumference of a circle to its diameter; the perimeter and area of circle, sectors</li> <li>Basic understanding of figures of axial symmetry</li> </ul>
Position	<ul style="list-style-type: none"> <li>The language of position</li> <li>Modelling and sketching the position of objects</li> <li>Informal grids and mazes</li> <li>Using coordinates to describe position</li> <li>Investigating aspects of position, focusing on mapping</li> </ul>	Not included in Chinese curriculum
Graphs	<ul style="list-style-type: none"> <li>Pictorial representations of groups of objects</li> <li>Comparing groups of objects that represent other objects</li> <li>Comparing groups of objects by representing with tally marks</li> <li>Column graphs</li> <li>Picture graphs</li> </ul>	Under the strand of statistics <ul style="list-style-type: none"> <li>Statistical tables</li> <li>Bar chart</li> <li>Pie chart</li> </ul>

# From a Classroom Teacher to a Teacher Educator: My 50 Years in Mathematics Education

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**Abstract:** This paper is a self-reflection on the author's journey from a classroom teacher to a teacher educator during her 50 year-career in mathematics education. The author summaries her educational journey into three changes and development from tracking students' high scores to pursuing quality of mathematics education, from personal pursuit for teaching success in mathematics to a team leader, and from a classroom teacher to be the current chairperson of the National Teachers' Federation for Mathematics in Primary Education. She started "Wu Zhengxian Mathematics Teacher Workstation" from 2008 with the support of the Beijing Academy of Educational Sciences, where she has led 72 mathematics teachers and formed a learning community for practicing child-friendly mathematics education. She also created the notion of "engaging children with 'tasty and nutritious' mathematics learning experience", which has spread throughout China.

**Keywords:** Mathematics teacher, teacher educator, mathematics education, primary school, Wu Zhengxian, Beijing

## 1. Introduction

When I started writing this article, my heart is filled with emotional memories which have lingered for 50 years. Opening the memories for half a century, and the unforgettable fragments are connected into a colorful educational dream-catching career path.

In the midsummer of 1970, my educational journey set off as a teacher from a little-known primary school in Beijing, China. I taught Chinese and mathematics and worked as a classroom teacher for 25 years in Beijing. Later, I was selected to act as a teacher mentor (also known as "Jiaoyanyuan"), first at district and then at municipal levels for nearly 25 years. Looking back on my journey from a classroom mathematics teacher to a mathematics teacher educator, I feel very much rewarded with my dedicated career.

I have made significant progress along with the evolution of China's Open and Reform policy and in particular the national education reform. In this paper, I would like to recall the changes and development of my educational journey from tracking students' high scores to pursuing quality of mathematics education, from personal pursuit for teaching success in mathematics to a team leader, and from a classroom teacher to be the current chairperson of the National Teachers' Federation for Mathematics in Primary Education.

## 2. From Tracking Students' High Scores to Pursuing Quality of Mathematics Education: Exploration of Child-friendly Mathematics Education

I officially embarked on the journey of education in the early 1970s and started my career as a teacher at the age of 16. At that time, the mis-leading belief that "school education is useless" prevailed in Chinese society. Consequently, educational routines were disrupted, teaching order was interrupted, and all schools almost lost their due educational functions. Fortunately, it soon arrived the turning point in 1978. With the triumphant convening of the Third Plenary Session of the Eleventh Central Committee of the Communist Party of China, the consciousness of "knowledge is power" and "respect for knowledge and respect for talents" has returned. Sucking the fresh air of the times, my heart was filled with endless excitement, and my body seemed to have inexhaustible strength. I devoted myself to work, leaving early and returning late, and working day in and day out. As a result of my diligent work, the graduating class (Year 6) I taught achieved excellent results for years. The total scores of the students I tutored in the Math Olympiad have been among the best in the district for many years, and the students were enrolled in the best middle schools for

their academic excellence. When I rushed towards the goal of improving the key points and getting high scores, I was always enjoying it in a so-called "efficient" class.

But, one day, I suddenly found that in the class, my students' expressions were a little numb, their eyes were a little sluggish, lacking curiosity and enjoyment. Apart from my dominant teaching, there was no participation of children and consequently the atmosphere in the class became more lifeless and some students became reluctant to learn. This made me feel painful and uneasy. I came to ask myself: "Why? Is this the correct way?" "How to change this state of teaching and learning? A strong sense of responsibility and mission was condensed in my heart. I was then determined to explore a new approach to reduce the burden, to encourage students to develop actively and thus to improve the quality of teaching and learning process .

Under the guidance of my inspiring mentors Mr. Liu Mengxiang and Mrs. Ma Xinlan, two outstanding experts in mathematics education, I started my experiment to engage students in learning mathematics. I boldly changed the structure of teaching materials with an intention to build a close internal connection of knowledge and the cognitive laws of students. To focus on the key concepts, I reintegrated scattered and fragmented knowledge into six related knowledge systems for teaching (abbreviated as "Six Dragons" teaching), guided students to communicate the internal connections between knowledge, to construct their mathematical knowledge into a knowledge network, to form a three-dimensional knowledge module with clear context, and finally to let the mathematical knowledge form a systematic structure in the students' minds. Such an approach aimed to help students learn to look at problems from a holistic, inter-connected, and developmental perspective, with a sustained intention to integrate knowledge and the learning methods, and thus to prepare students with a universal method for understanding things. The structured content gave students opportunities to continuously understand, think deeply and apply the most basic concepts, shorten the psychological distance between students and mathematics, and enable students to have the confidence and ability to learn actively and independently. As I look back even today, my personal approach seemed to prove highly similar to the philosophy of the current deep learning concept.

In classroom practice, I changed the traditional method when teachers spoke most of the time while students had to listen. Instead, I employed a variety of learning methods to engage students with self-study,

group discussion, exercises for problem-solving. Based on such endeavors, I discovered a dozen of strategies such as correspondence, hypothesis and transformation as tools to stimulate students' thinking ability. In terms of assessment methods, I proposed to change the paper-pencil test mode to combine both closed and open-ended tests, formal examinations, and classroom interactions with attention to assess both knowledge acquisition and competence development. In terms of content, the previous emphasis was on knowledge and now on students' ability to solve practical problems. In terms of form, the past practice merely on paper work was then extended to include various forms of "written examination + oral examination + operation". The new approach encouraged students to use their mouths, hands, and brains to express their ideas. For the final evaluation, I tried to assess students both with their performance throughout the whole year and their final examination. Besides, students' creative thoughts, novelty, and originality in solving problems were awarded with extra credits. In case some students failed with exam once, they might get a second chance to make corrections with special assistance. Consequently, there were often moving scenes in the classroom where students were all interested in learning, active in thinking and they now became eager to learn, knew how to learn, and most of them were good at learning.

This experiment made it possible for students be able to complete the two-year mathematics course in one year without additional hours. Students took part in the graduation examination on mathematics one year in advance and their grades were higher than the district average! In the experiment, the students' interest in learning mathematics, thinking ability, especially the ability to solve practical problems were significantly enhanced. Later, the experiment was acknowledged as an innovation and won the "Beijing Educational Scientific Research Achievement Award".

However, my deep interest in theoretical enquiry was aroused with the introduction of the national curriculum reform basic education which began in 2001. The new curriculum advocated a learner-centered paradigm that emphasized the three-dimensional goal to transmit knowledge, to inspire potential and enrich personality responded well to my previous experiment, which made me extremely excited. I immediately became fully involved to this new curriculum reform. Since then, the "three-dimensional goal" went to stay in my heart, giving me a clear direction for teaching reform. I was not only concerned about the students' performance, but also started to focus on the process and



the physical and mental growth of the students. I began to perceive every change of the students with my heart and motivated them every bit of progress with enthusiasm. I began to use my brains to think of ways to create a supportive learning environment for students that was conducive to their learning and growth. In the eyes of students, I was no longer a "flat teacher" who only taught the knowledge, but a "three-dimensional teacher" who is now full of flesh and blood, full of affection and love, and can share with them wisdom and joy.

The new curriculum reform made me feel deeply that education has developed from the past "knowledge center" and "competence center" to "student development as the center", and the focus of education has undergone a complete change. The new curriculum reform provides a critical opportunity for all teachers to practice quality education with the essential characteristics of improving students' comprehensive quality, and to provide students with an important opportunity for integrated development.

In 2002, I was officially transferred to the Beijing Academy of Educational Sciences as the head of the primary school mathematics teaching, which gave me a chance to work at the municipal level with all Math teachers in Beijing. In order to do a good job, I first conducted an extensive and in-depth investigation of the mathematics learning status in the primary schools in Beijing. I found that the main problems were that students lack interest and confidence in mathematics learning and lack effective learning methods. To solve these problems, I launched the pilot project on "Creating Children's Favorite Mathematics Classroom", which laid the foundation for my child-friendly mathematics education theory and practice.

Guided with children's psychology and learning theories, I organized local mathematics teachers to actively research, explore and practice. According to the characteristics of primary school mathematics and the children's learning needs, I created special classroom environment in favor of learning, that is instrumented with genuine feelings, hands-on learning, interactive, stimulative, cooperative, and enjoyable atmosphere. Such classes closely focus on the core of "promoting children's development", guiding children to be full of curiosity, interest, and thirst for knowledge in learning, allowing them to experience an unforgettable learning process, obtain rich and unforgettable experience in mathematics activities, and have the knowledge of mathematics learning, with confidence and good feelings.

In the process of advancing the teaching reform of primary school mathematics, I led teachers to work hard to create classrooms that children love. In teaching, while paying attention to students' understanding and mastering knowledge and skills, we also paid more attention to the overall performance of students' learning process, to students of different development levels, thus, to arouse students' active engagement in the process of mathematics learning, which made the teaching process as an important journey for every student to experience progress and success.

In 2008, I proposed the proposition of "delicious and nutritious"(both enjoyable and quality oriented) children's mathematics teaching. I re-examined primary school mathematics teaching from the perspective of children's psychological development needs and cognitive laws. I came to recognize that children need mathematics knowledge and abilities that are "golden in content", and they need to carry out learning activities in a "fit" way. The dual value orientation has become an indispensable focus of teaching. To provide children with "nutritious" mathematics learning, it is necessary to choose valuable and rich learning resources, grasp the essence of mathematics for teaching, set the standard for basic knowledge, and pave the way. To provide children with "delicious" mathematics learning, we must pay attention to children's psychological needs, follow the children's age characteristics, create fun and interesting learning situations, and design children's favorite mathematical activities. We need to make meaningful mathematics interesting and make interesting mathematical activities meaningful. We also need to adhere to the law of mathematics teaching and the law of children's learning, which are organically combined.

In order to let children have an enjoyable learning experience and obtain tangible progress and growth, I constructed a three-dimensional coordinate system of "Children's Subject Education" (See Appendix 1: Figure 1).

In this coordinate system, "child" is clearly written on the vertical axis of the upright position. As a teacher, we must first take every child at heart. Caring for children is the key to a good education. Teachers must respect every child and follow the law of children's cognition so as not to fall into the subject standard. The horizontal axis extending to the right in the coordinate system is "subject". Teachers can only devote themselves to the study of subject teaching, grasp the nature of the subject, and give full play to the advantages and functions of different subject teaching, so that subject teaching will not deviate from the track.

The third axis of the coordinate system that stretches out to the distance is "education". Education is the understanding and communication between people and the interaction between people. Education unifies children and subjects harmoniously, arouses children's interest and confidence in subject learning; education is to let children feel the meaning and value of subject learning in an appropriate way, experience the wide application of knowledge and unique charm, and make children love learning, be good at learning, know how to learn, and be able to learn, to effectively improve children's core literacy and learning ability.

With the deepening of curriculum reform, I have increasingly promoted new core achievements, which are an important foundation for human growth and development. The growth of core literacy is the soul and foundation of teachers. Changing the way of learning is a way for children to develop their abilities. In a word, during my 50 years of educational journal, from tracking students' high scores to pursuing quality of education I followed the curriculum reform all the way.

### **3. From "One Person" to "a Team of Colleagues": Building a Mathematics Teaching and Research Center**

In 2008, when the curriculum reform was in full swing, the Basic Education Research Center of Beijing Academy of Educational Sciences established the "Wu Zhengxian Primary School Mathematics Teacher Workstation", where 72 outstanding elementary school mathematics teachers and teaching researchers from Beijing formed a learning community for learning, researching, and practicing children's mathematics education, which became a kind of fire for spreading and radiating children's mathematics education. As the host of the Workstation, I develop the idea of "delicious and nutritious" children's mathematics education, which spreads in Beijing and even the whole country. From then on, I started to build a mathematics teachers' team from "one person" to "a group of people".

"Wu Zhengxian Primary School Mathematics Teacher Workstation" has determined our team development goals, work objectives and research plans. It aims to explore the successful teaching practical experience and research results of outstanding teachers as a curriculum resource to lead the professional development of grassroots teachers; try to use team teaching and research service methods to work at the grassroots level. In response to teachers' actual needs, we organize front-line teachers to carry out a rich and diverse series of training and follow-up practice, and

follow-up research; in the process, we explore to cultivate teachers to be sentimental and capable, able to attend classes and research, and lead the other surrounding teachers to grow together as resource-based backbone teachers.

In more than ten years of teacher team research and training, 72 team members and myself jointly drove the teachers in the suburbs and counties of Beijing, formed a multi-participation and multi-benefit training mechanism, and constructed six practical and effective teacher team training strategies, namely: leading by famous teachers, absorbing professional nourishment from successful experience; lesson study, with the aid of carefully organized teaching process to carry out behavioral intervention, after-school interviews, an important resource for teachers' professional growth, peer mutual assistance, interactive construction to generate teaching practical knowledge. We established a '1+10+N' radiation cooperation research and training mechanism and resource construction, based on the study of teaching practice strategies.

The workstation uses a brand-new teacher team-building model to create a vivid classroom seminar environment, leading every teacher to actively participate in interactive training based on lesson examples. Teachers changed from "designed and trained by others" to "designed and trained by me", which effectively attracted the full participation of grassroots teachers, stimulated the strong internal and professional development needs of grassroots teachers and their enthusiasm for teaching work, and relieved many teachers' enthusiasm.

The workstation overcomes the scale limitation of face-to-face teaching and creates a "Teacher Network Training Course", which gives full play to the advantages of online education that is not limited by time and space. It also created a 1:30 learning class formed by the tutors and students, conducted one online topic Q&A every month, and completed assignments for related modules. A constantly updated network resource platform has been created, which has successively provided quality-guaranteed new curriculum research services for thousands of front-line mathematics teachers in rural counties in Beijing's outer suburbs and has also helped in-service teachers effectively resolve the contradictions between work and study. We have also established rural workstations in 10 districts of Fangshan, Huairou, Miyun, Mentougou, Yanqing, Pinggu, Shunyi, Changping, Daxing, and Tongzhou, achieving full coverage of rural areas in Beijing and generating thousands of grassroots teachers. It has a

positive impact and promotes the balanced development of basic education in Beijing.

For more than ten years, the workstation has cultivated a large number of excellent teachers and brought up an excellent backbone teacher team. The members of the team work hard to study and practice and play a leading role in the grassroots schools. We have carried out special research on teaching innovation and practice. We have published more than 20 series of team achievements and a considerable number of video and image materials. Many articles have been published in educational magazines, which have been highly evaluated and widely used in the national primary school mathematics community as research resources for the professional development of mathematics teachers.

The team's training process has made me deeply feel that team training is an effective means to promote the professional growth of teachers. For curriculum reform to succeed, it must arouse the overall progress of more teachers, from "one person" to "a group of people", using a group of people to influence more people, and allowing excellent educational resources to continue to expand.

#### **4. From A Classroom Teacher to A Teacher Educator: My Path to Growth**

With the gradual deepening of the curriculum reform, I also entered a more rational thinking stage. I once again asked about the nature of children's education and the value of children's mathematics education. Slowly, a clear line of thought appeared in front of me, and the ultimate goal of education is to make children happy. "Leaving morals and focusing on the cultivation of core literacy" is the foundation of education and the soul of education. It must become the essence of education. The starting point and destination, we can never forget our original intention. Therefore, I put forward the proposition of "from mathematics teaching to mathematics education", calling for mathematics teaching to change from pure mathematics teaching to rich mathematics education, to achieve the purpose of promoting children's all-round development. When we further asked, "how to implement morality and cultivate people and cultivate core literacy in specific mathematics teaching", a clear line of thought was further formed, which is to tap the potential of educating people in mathematics teaching. Mathematics education is a process of human rational exploration and the subtle influence of the spirit of seeking knowledge, a process of mathematics cultural inheritance, an

educational process of perfecting personality, and a practical process of exploring the unknown world. For the first time, I put forward the "five signs of rational spirit in the growth of children's personality", namely: honesty and trustworthiness, observance of rules, adherence to responsibilities, perseverance, and self-reflection. Let the process of learning mathematics become a process of cultivating a healthy personality and core literacy, and truly realize morality and cultivation.

Looking back on the 50 years of teaching, I firmly believe that the core of children's education is to promote the happy growth of children, and the core of teacher education is to promote the overall improvement of teachers' feelings and profession. We must take children to heart, do warm education, and make the classroom full of humanity; we must take teachers to heart, do wisdom research, and let teachers obtain professional happiness. For 50 years, I have not forgotten my original intention. There are hardships and ups and downs, but it is full of joy and happiness. Being a good teacher and a good researcher is the direction of my efforts.

In 2009 I was nominated by the China Education Society to act as chairperson in charge of the National Federation of Primary Math Teachers. Since then, I started to expand my services to as many as teachers all over the country.

Therefore, in the process of deeply participating in curriculum reform, I always ask myself to go deep into the grassroots to conduct research and understand the situation. I put forward several proposals at the Chinese National People's Congress, such as "on environmental protection", "on the issue of elderly care", "on the issue of reducing the excessive burden on students", "on the issue of teachers' treatment in remote rural areas" and so on. These proposals have received positive responses from relevant state departments, and some opinions have been adopted. I work hard to assume social responsibility, offer advice and suggestions for the development of education, and contribute my modest contribution to social progress.

In summary, looking back on the past, I have been fortunate that the course of my professional life has coincided with the prosperity of the motherland's reform and opening up. It is the vigorous development of my country's basic education under the influence of "reform and opening up and emancipating the mind". It has built a broad platform for my growth. I use my persistence and enthusiasm has sowed hope in this hot land of education and reaped the happiness of the

teaching profession. Based on years of unremitting research and practice, I independently wrote and published a series of mathematics monographs including "Wu Zhengxian and Primary School Mathematics". My research papers have won many awards and have had a certain influence in the field of primary school mathematics. As a member of the Ministry of Education's primary and secondary school textbook reviewer, I participated in the review of national primary and secondary school mathematics textbooks; I participated in the review and revision of the compulsory education mathematics curriculum standards (2011 edition and 2021 edition). In 2021, I was invited to give a speech on "Tasty and Nutritious Mathematics Education for Children" at the 14th International Conference on Mathematics Education. The topics related to "Children's Mathematics Education Research" and "Teacher Professional Development Research" I presided over won the first prize of teaching achievements issued by the China Ministry of Education and the Beijing Municipal Government. I look forward to more children who can enjoy "delicious and nutritious mathematics education", and I look forward to more teachers who can enjoy the happiness and joy of professional life.

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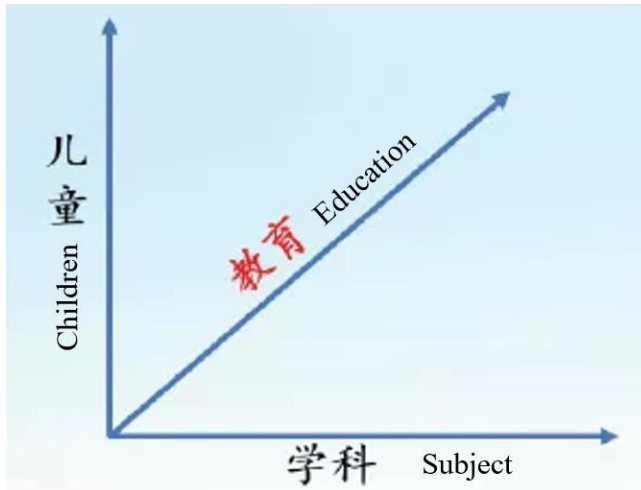
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**Appendix 1: Figure 1: A three-dimensional coordinate system of "Children's Subject Education"**



# Exploring Collaborative Online Problem Solving as Opportunity for Developing Primary Students' Positive Mathematical Identity

*Duncan Symons, Robyn Pierce, & Christine Redman*

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**Abstract:** Identity, as a “math person” or not, develops as a result of a myriad of micro-events. This paper uses positioning theory as a lens through which to view the interaction between two year-five students, within a computer supported environment, in the context of collaborative mathematical problem solving. Findings from analysis of the micro event show unexpected confidence from one student but also a power imbalance that ultimately impacted levels of mathematics agency for both students. The lens of positioning theory drew attention to features of the interaction revealing aspects of each student’s identity, including mathematical identity, which might otherwise remain unnoticed.

**Keywords:** Collaborative online problem solving, mathematical identity, positioning theory, primary students

## 1. Introduction

We have all met someone who, as part of their identity, states, “I am not a maths person”. This identity has formed over time and through many micro experiences. Identity has been recognized as an important indicator of continued study in mathematics (Jorgenson, 2015). Mathematics identity, as well as one’s beliefs about mathematics, and what it means to be a successful learner of mathematics, are the components of “productive disposition” highlighted in the seminal book “Adding It Up” (Kilpatrick, Swafford & Findell, 2001, for the United States National Research Council). Those authors proposed that mathematical proficiency is composed of five interrelated strands: conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and productive disposition. With this braid of strands in mind, mathematics educators strive to provide opportunities for students to not only construct knowledge but also to develop a positive relationship with mathematics. Such occasions may occur in different contexts for different students and so educators look for new possibilities, for example those opened up by information and communications technology (ICT). In Australia the national curriculum documents explicitly state that teachers are expected to make use of technology for learning and communicating

mathematical ideas and concepts. For example, the Australian Curriculum (ACARA, 2014) promotes this theme in the following statement:

Students develop ICT capability when they investigate, create, and communicate mathematical ideas and concepts using fast, automated, interactive and multimodal technologies. They employ their ICT capability to perform calculations, draw graphs, collect, manage, analyse, and interpret data; share and exchange information and ideas and investigate and model concepts and relationships. (ACARA, 2014)

Mathematically able software, drill and practice tasks and games are readily available through the internet. An online environment can also provide opportunities to broaden students’ experience of both doing and communicating mathematics, in particular through collaborative online problem solving. Digital technologies, now available across Australian classrooms, offer an alternative to the face-to-face classroom environment: one that is not only familiar to today’s students but also one where social dynamic may differ from the face-to-face setting. The use of digital technologies may thus offer new opportunities for developing each of the five strands of mathematical proficiency. Analysis of records of on-line interactions may provide teachers with further insight into the development of students’ mathematical identities.

However, research on students' communication when engaged in mathematical collaborative online problem solving, is limited, especially at the primary school level.

This paper reports on the use of positioning theory (van Langenhove & Harré, 1999) as a lens to analyse student interactions in a computer supported collaborative space. Specifically, this paper provides a detailed report of a trial of the application of this methodology on order to address the following questions:

Can positioning theory assist in the identification of perceptions of self and so track changes in students' micro-identity as they interact with peers within a primary school level mathematical online collaborative learning environment? If so, what can we learn from these interactions?

This research adds to the work of Wood (2013) who used positioning theory to study a Year 4 student's micro-identities as enacted across mathematics lessons. She noted that considering micro-identities "allowed for a more nuanced understanding of the complexities of learning moments creating the possibility of enhancing mathematical learning for all students" (p.806).

Since the application of positioning theory requires fine detailed analysis, for this paper we have chosen to demonstrate the examination of the interactions of just two participants. The results of this study are not intended to be definitive but to indicate the potential value of using positioning theory to analyse interactions and storylines evident when primary school students participate in online collaborative problem solving.

Below we provide a brief background on CSCL environments and positioning theory. Next, the details of the context of the study are described. This is followed by results, discussion and then conclusions about the mathematical identity issues revealed by positioning theory and some implications for researching primary school mathematics within the context of a CSCL environment.

## 2. Computer Supported Collaborative Learning

CSCL takes place via the vehicle of technology (computers) typically linked via an intranet or the Internet. The collaborative learning referred to here is described by Dillenbourg (1999) as occurring when peers who are at more or less at the same level perform the same action, have a common goal, and work together.

Research analysing the contributions and roles taken by students in CSCL are limited and no significant research at the primary school level was identified in the

relevant education literature. In studies undertaken in University settings researchers have shown differences in the volume of contributions that males and females make within CSCL environments. Prinsen, Volman, and Terwel (2007) who conducted a review study, inclusive of 13 articles, into gender-related differences within CSCL environments concluded that males tend to be more dominant and assertive within these environments, whilst females tend to take a more collaborative approach, build on each other's ideas, and generally agree more (2007, p. 406).

Gerry Stahl (2011), a pioneering researcher in the area of CSCL embedded mathematical problem solving at the upper secondary and tertiary level, argues that previous research into CSCL is not grounded in theories that explicitly investigate group interaction. He suggests that previous approaches to the study of CSCL have been grounded in theories that either focussed exclusively on individual roles or more broadly analysed the role of the individual within the larger group. He argues, that in order to understand how the group constructs knowledge, we must examine and explore the interactions that occur between participants within the CSCL environment.

## 3. Positioning Theory

This study focuses on students' interactions and is framed by positioning theory which Harré and van Langenhove (1999) describe as:

the study of local moral orders as ever-shifting patterns of mutual and contestable rights and obligations of speaking and acting [where local moral orders are] the local system of rights, duties and obligations, within which both public and private intentional acts are done. (p. 1).

In a CSCL these local moral orders may relate to who starts the discussion, how long the posts should be, what writing style is accepted, how quickly replies should be posted; and so on.

Researchers have identified participants' positioning within CSCL environments as an under researched area (Dennen, 2011). Some research has been undertaken into the ways in which facilitators (or instructors) position themselves with respect to the students and, reciprocally, the ways in which students position the instructor within CSCL environments (Dennen, 2011). However greater understanding of student to student positioning in CSCL is required if we are to understand how working in such an environment may impact on students' mathematical identity.

Davies and Harré (1990, p. 57) provide a systematic approach which may be used to undertake an analysis of discourse informed by positioning theory. They reiterate that only through examining “utterances” relative to the range of story lines at play within a given context can these speech acts carry weight and meaning. Redman and Fawns (2010) give special consideration to the use of pronouns by participants. They note that changes in pronouns can highlight the active, moment by moment, positioning and repositioning of participants.

#### 4. The Study

In this paper we used positioning theory as a lens through which to analyse one excerpt of student-to-student interaction in a primary school CSCL environment. Interaction was recorded in the transcript of students' online discussion and viewed within the context of position, storyline, and “speech” acts. The episode analysed took place during a ten-week teaching intervention with 54 Grade 5 (10–12-year-old) students in a lower to middle class suburban primary school. Over the ten weeks students worked collaboratively on 9 mathematical problems set from across the curriculum.

The CSCL environment was developed within the Edmodo online ‘social learning platform’ (Edmodo, 2014) because it supports teachers to set up ‘groups’ and allows various artefacts to be uploaded (Excel spreadsheets, Word Documents, images etc). Importantly, the participants had a little prior experience of this platform and given the age and ICT inexperience of these students, the platform is relatively intuitive to negotiate.

Neither the class teacher nor the researcher (first author of this paper) contributed directly to the students' online discussion. The decision, to not have an adult facilitator, was taken to avoid the communication between students being inhibited or heavily influenced by someone they perceived as an expert. However, the students were supported during weekly, face-to-face, whole group classroom sessions with the researcher. Since online discussion was a new experience for these students the researcher initially spent time discussing approaches to collaboration respectful of each member of their on-line group. Each week he reviewed the previous week's solutions and discussed any challenges and successes that students perceived. Next, he explained and read through the following week's problem.

The advice provided in the research reports of Davies and Harré (1990) and Redman and Fawns (2010)

informed the approach taken for our analysis of student interactions in the CSCL. Unlike much of the dialogue recounted and interpreted within the literature that has informed it, interactions examined in this study occurred asynchronously between primary age children in an online environment. As a result, discourse between students was less ‘naturalistic’ than typically occurs in the face-to-face environment. Students' disjointed discussion required, at times, the use of contextual clues to infer participants' meaning.

The pair of students exemplified in this paper were a girl, Oleander and a boy, Zander (pseudonyms have been used). Oleander was from a home language background other than English and had been assessed by her teacher as ‘below level’ in mathematics. Zander had been assessed as ‘above the expected level’ in mathematics. While the teacher's assessment was not explicitly revealed to the students, in class they were often set work in like ability groups. Oleander's contribution to discussion varied between online and face-to-face interactions. Jazby & Symons (2015) reported that Oleander made fewer and shorter contributions in the face-to-face environment as compared to the online environment. Whilst she contributed 39% of total posts at an average length of 20 words per post in the online environment, Oleander only provided 19% of contributions within face-to-face interactions, averaging 19 words per utterance.

Oleander and Zander were part of a heterogeneous group of four students, two of whom chose not to contribute to this particular discussion. In terms of their positioning Oleander and Zander would have expected the other two to at least read their posts. Researchers (Boaler, Wiliam, & Brown, 2000; Clarke & Clarke, 2008) report on a range of concerns about the long-standing tradition of streaming within western educational settings. These concerns include the tendency for teachers working with the lowest attaining mathematics class to deliver work of a tedious, rudimentary, and non-challenging nature. In this study all students tackled the same problems. As a consequence, a storyline influencing data analysis focused on the position of Oleander in the small heterogeneous group where the lesson content demanded higher order thinking and whether the online environment may elicit more productive discussion and provide illuminating insights into student identity.

#### 5. Results and Analysis

To demonstrate the fine-grained analysis required to apply positioning theory, one episode of dialogue



between Oleander and Zander has been analysed (see below). This was typical of discussions that had occurred throughout the CSCL environment and offers an opportunity to explore the value of the positioning theory lens for analysis of students' online mathematical discussion. The task that the students are working on is included below in Figure 1.

Week 4 - How big is a dog?	
Problem	What is the biggest breed of dog?
Problem steps	<ul style="list-style-type: none"> <li>• Research a variety of dogs using your netbook.</li> <li>• Decide what 'biggest' means. Provide a definition. Your group will have to decide whether they think 'biggest' means heaviest, tallest, longest etc</li> <li>• How do breeders measure this?</li> <li>• Create a graph in Excel representing the data you have found.</li> <li>• Horizontal axis (x axis) should be breed of dog and vertical axis (y axis) should be height/ weight/ length etc.</li> <li>• Upload the graph that you have made to this message board.</li> <li>• Which dog according to your definition is the 'biggest'?</li> <li>• Can you discuss any other facts that you can 'read' from the graph that your group has created?</li> <li>• Now think about another measurement you can use to define 'biggest'. E.g., If you defined 'biggest' as height of the dog last time, you might like to use weight this time.</li> <li>• Create a new graph.</li> </ul>

**Figure 1. The problem discussed by Oleander and Zander**

Sequential utterances by the two students (Oleander and Zander) have been provided (verbatim) in italics. Analysis has been provided (where appropriate) below each utterance.

1. Zander: In our group I think we should make the word "biggest" dog mean the "tallest" dog.

Zander chooses to initiate the discussion by appealing to the group through utilizing the pronoun 'our'. In this way he seeks to empower all group members to take up this position. He reverts to the more assertive 'I' and shares his belief that 'we' (the group) should define the 'biggest' dog based on the variable of height. His sense of agency is strong, and he positions himself as a leader.

2. Oleander: Yea and it also could mean the weight in my opinion?

Oleander suggests an alternate (but equally valid) option when she states that 'it' could be defined by using weight as a variable. Her statement indicates that she understands the problem and she positions herself as a group member willing to contribute to moving the problem forward. Whilst, a micro identity of

mathematical confidence is displayed here, a general sense of resignation that her view will not be accepted is apparent. This is evidenced through her use of the words 'in my opinion'. This takes away from her agency, as it acknowledges that her offering is open to debate. This is compounded by her choice to attach a question mark to her statement. A sense of mathematical confidence and an awareness of a lack of agency are simultaneously displayed.

3. Zander: These are some breeds of dogs that are very tall. The world's tallest dog is Giant George. He is registered as a Blue Great Dane. He is 109.2cm tall. [details of 9 more breeds]. These are some breeds of dogs that are very tall. ...

Zander chooses to ignore Oleander's contribution and re-affirms his stance that the variable the group will use to describe 'biggest' will be height. By removing any pronouns, he maintains his position. Zander does not seem to have felt challenged. Perhaps despite Oleander's contrary viewpoint he does not feel a need to reposition himself. Zander continues to position himself as 'leader' and therefore 'decision maker' within the group.

4. Oleander: I'm thinking of doing the last one? What would you prefer?

Again, Oleander's repetitive use of question marks to frame her suggestions indicates a possible lack of confidence. In addition, she positions herself as a group member committed to consultation and collaboration. Whilst, she had made her determination she is open to change. This is reinforced by her choice of asking Zander what he would prefer to do. Here whilst her potential motivation is to engage in 'collaboration' she positions Zander as the authority and 'decision maker' and implies that she will be amenable to his judgments.

5. Zander: Me too.

6. Zander: Going back to the tallest dog, you cannot make 2 opinions. You can only make 1. And I believe that it should be the tallest with our group. Unless when you're doing the last bit of the work. Then you can do another opinion.

Zander chooses to refocus the discussion on his stance that biggest should mean tallest. The use of the pronoun 'you' repeatedly and insistently reiterates that the group must come to a consensus about what 'biggest' should mean and that the group should agree with his viewpoint. His use of the words 'I believe' is powerful and shows that he is operating on the faith or belief of others within the group. He is hopeful that other group members will be faithful and follow him. He continually positions himself as the authority and leader within the

group, and resultantly positions Oleander as having less to offer. By explaining that 'you can only make 1 (opinion) he positions himself as a person of greater authority within the group.

Zander's chooses to soften his stance by suggesting that Oleander's opinion may be of value in the last part of the work. Having positioned himself as leader within the group, he allows Oleander to employ her suggestion once the bulk of the work has been completed.

7. Zander: I think the tallest dog in our case is the Blue Great Dane, or the other two options could be the Anatolian Shepherd, or the English Mastiff.

8. Oleander: Okay then we would just do the tallest. Mine [be]cause it could be said. In 2 ways and for our group it could be tallest.

Oleander chooses to accept Zander's directions. Her statement of 'we would just do the tallest', shows that she understands that the group does need to come to a consensus on the issue and that she is unwilling to debate the matter further. She would be positioning herself as defeated, if not for her final statement showing she knows that her original idea of using weight as the variable to indicate biggest is still valid but to save further argument is happy for the matter to be resolved. The two participants' positions in the local moral order, of members of the 'top' mathematics stream and member of the 'bottom' mathematics stream in addition to their genders may influence the storylines. The two storylines frame and inform us about interactions between Zander and Oleander. The two storylines shown to be impacting on the power and identity of participants are related to their positions in the local moral order. These storylines inform us about interactions between Zander and Oleander.

It is evident from the above analysis that Zander chooses to take an assertive and dominant position within the online space. The following exchange exemplifies this:

Zander: You cannot make 2 opinions. You can only make 1. And I believe that it should be the tallest.

Additionally, we see evidence of Oleander choosing to take up the position of a collaborative group member, open to other students' ideas and committed to finding agreement. This is represented as she negotiates:

Oleander: I'm thinking of doing the last one? What would you prefer?... Okay then we would just do the tallest.

It is notable that during the physical classroom discussions, a clear learning focus was on how to approach collaboration within the online space. By

week 4 of the study, when the interaction above took place, collaborative guidelines had been discussed in detail. It is evident from the dialogue that Oleander has internalized these expectations and Zander either does not need to do so or does not see this as a part of the intended learning outcome.

A significant observation representative of the stark differences in the positioning of the two participants is that Oleander regularly phrases her ideas as questions to be decided upon i.e., for consideration, whilst Zander never chooses to frame his ideas using this approach.

A consequence of the students positioning themselves in this way is their resultant positioning of each other. That is, a result of Zander positioning himself, as a dominant authority/ leader is that Oleander is positioned as having reduced agency and therefore is disempowered. Oleander consistently repositions herself as a collaborative group member, open to ideas and working towards agreement. However, this results in Zander assuming a position of power that is relational, (Redman & Fawns, 2010, p. 176) and acting on this, indicates a degree of agency within the group, based on perhaps, the local moral order in the classroom and the local conventions of social practice. Zander identifies himself as a leader, and signals this to others.

## 6. Conclusions and Implications

The aim of this small-scale study was to determine whether positioning theory might help to investigate students' micro-identity, as demonstrated in collaborative online mathematical problem solving.

The dialogue makes apparent that in this instance, Oleander's problem solving, and reasoning is of a similar level to that of Zander's. However, the identified storylines signal that her contributions are being dismissed. Students are commonly put into like ability groups according to their mathematical procedural ability and fluency. These areas of mathematics are more easily assessed regularly. This study reveals that despite the 'below level' macro identity assigned by her teacher Oleander saw herself as having a valuable contribution to make to the problem solving. Her willingness to express her views to the 'above expected level student' in this online environment is all the more interesting because in face-to-face group interviews, conducted by the researcher, Oleander was reluctant to take part (Jazby & Symons, 2015).

The value of Positioning Theory here is that it helps us to recognize that we establish our microidentities relationally, influenced by the local

moral order. That is, through our interactions with others. Zander chooses to assert his micro-identity as leader and mathematically confident. Throughout the episode we see a struggle, between the students as to whether his attempt at claiming this mantle will be legitimised. Whether, or not he is successful with his goal impacts on Oleander's micro-identity. If he succeeds, to an extent, her identity, as being capable of providing valuable mathematical ideas and contributions is negatively impacted. Whilst, if Oleander's views were recognised and acted on then her identity in this instance, of being a valuable 'mathematical' contributor would be realised.

Complicating matters further is Oleander's desire to conform to the micro-identity of 'collaborative group member' promoted by the researcher in their class sessions on appropriate on-line behaviour. In this instance a desire to assume the micro-identity of collaborator seems to be in tension with her acquisition of a micro-identity associated with valued and accepted contributor of mathematical ideas and thinking.

In this paper we have viewed one episode contributing to the development of the micro-identities of two students. It may be of interest in the future to view the unfolding narrative in discourse beyond this episode. This may allow insight into the changing nature of student mathematical micro-identities'.

The focus on analysis of pronoun use also appears to be worthy of further consideration. Whilst this focus illuminated aspects of the positioning of Oleander and Zander, in the context of working in the online environment, it was possible to gain further insights through closely examining punctuation. For example, student use of question marks could at times indicate a lack of certainty or confidence. Whilst they were not used in dialogue in this study, analysis of emoticons may also be helpful for analysis of positioning within the online environment.

Previous studies, with older students, suggest that girls are more collaborative than boys in a CSCL. This was the case with Oleander but her tentative approach and willingness to give way to Zander is also consistent with micro-identities resulting from their teacher assigned classroom grouping. Research also shows the negative impact on perceptions (the identity of oneself and others) that ability grouping can produce. Asynchronous on-line work allows a student both time to think and the option to mask any insecurities.

The interactions in CSCL environments not only provide students with new opportunities to express their identity but also provide researchers and teachers with a

record that may reveal strengths, weaknesses, or levels of confidence not evident in the usual classroom. Oleander's contribution to this micro event provides an example revealing a moment of positive mathematical identity not apparent in the classroom. Through utilizing the lens of positioning theory within the CSCL environment we may be able to detect and respond to storylines impacting on students' mathematical identity that would otherwise remain untold.

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# The Future of Mathematics Education Since COVID-19: Humans-with-media or Humans-with-non-living-things

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**Abstract:** The COVID-19 pandemic has changed the agenda of mathematics education. This change will be analyzed by looking at three trends in mathematics education: the use of digital technology, philosophy of mathematics education, and critical mathematics education. Digital technology became a trend in mathematics education in response to the arrival of a different kind of artifact to the mathematics classroom. It was thrust into the spotlight as the pandemic suddenly moved classrooms online around the world. Challenges specific to mathematics education in this context must be addressed. The link between the COVID-19 pandemic and digital technology in education also raises epistemological issues highlighted by philosophy of mathematics education and critical mathematics education. Using the notion that the basic unit of knowledge production throughout history is humans-with-media, I discuss how humans are connected to the virus, how it has laid bare social inequality, and how it will change the agendas of these three trends in mathematics education. I highlight the urgent need to study how mathematics education happens online for children when the home environment and inequalities in access to digital technologies assume such significant roles as classes move online. We need to understand the political role of agency of artifacts such as home in collectives of humans-with-media-things, and finally we need to learn how to implement curricula that address social inequalities. This discussion is intertwined with examples.

**Keywords:** COVID-19, SARS-COV-2, humans-with-media, digital technology, philosophy of mathematics education, critical mathematics education

## 1. An International Survey in Two Rounds

It is not possible to predict the state of the COVID-19 crisis at the time this article reaches the reader. The effects of the pandemic, and the response to it, have been shocking — with lockdowns, masks, and respirators, etc.—and have left most people at a loss. Some “world leaders” say that the virus is “just a cold,” while others say we may take months or years to have things “back to normal.” There are even those who say that COVID-19 is just a test for a much more serious health crisis that may be still to come. What is certain is that throughout the world, things have changed dramatically and suddenly. The virus has hit all classes of society, though of course it has hit the poor harder. But what are the effects of the pandemic in mathematics education? One effect that was almost universal was a tendency to “go online”: shop online, meet friends online, and learn online.

We have moved online because COVID-19 is

caused by an invisible virus; it has no cure; and, without a clear pattern, it can cause the death of one person in a few days and cause almost no symptoms in another. Moreover, one may be infected and transmitting but asymptomatic for several days and then become very ill all of a sudden. Though not all “leaders” have taken their advice, most experts, and the World Health Organization (WHO) recommend social isolation as the main tool to control, slow down, and hopefully stop the pandemic. Suddenly, teachers, professors, and educational managers at all levels were put under pressure to develop (mathematics) education online, as the virus can be transmitted through physical contact—both between humans and between humans and non-living things.

Since the beginning of the official history of the International Commission on Mathematical Instruction (ICMI) in 1908, only war has interrupted the International Meetings of Mathematics Education (ICME), according to Menghini et al. (2008). This year, the ICMI decided to suspend ICME-141 for a different

reason: due to the risk of spreading the coronavirus, traveling, and gathering in groups would be unsafe. Some would say that ICME-14 was suspended due to a different kind of war: instead of generals in the background, and soldiers in the field, ready to kill or die, we have the whole of humanity trying to fight this non-living being, a virus. It is debatable whether the war metaphor is appropriate or not for this health crisis, but terminology aside, the crisis can lead us to some reflection on mathematics education. This essay will raise some questions to the mathematics education community that were caused by this non-living-thing: the virus SARS-CoV-2, which causes COVID-19.

Engelbrecht et al. (2020) reported that they had to change the conclusion of their survey paper on digital technology in March to April of this year, as it occurred to the authors that the paper could become dated even sooner than other digital technology survey papers. In normal times, such papers become old because digital technology changes so fast, and we rarely even have the time to implement a given technology in the classroom before a new one comes up. However, at this point, everything may become outdated, because we cannot predict the evolution of the COVID-19 crisis, nor whether a new crisis will follow it. The authors decided to include discussion about COVID-19 in the introduction and conclusion of the paper. At the end of the paper, they write:

The question is, what has this [COVID-19] to do with mathematics education and digital technology? Besides the impact on conferences and on the transforming mathematics classroom we may have to ask broader questions: Digital technology intensified traveling and our way of living, so it is also partly responsible for the present crisis. Is it possible that the use of digital technology can generate a similar crisis in mathematics education? Conversely, if the crisis lasts for a long period, would digital technologies be able to provide alternative ways to implement mathematics education? There is not much research on online mathematics education for young children, but if the crisis lasts for a long time, are we going to implement it without sufficient research? If the current crisis is over soon, are we going to develop research on mathematics education for a possible “COVID-2X” crisis? In this paper, among others, we have anthropomorphized media, talking about agency. The notion of humans-with-media as the collective that produces knowledge, may synthesize it, as we discussed in this paper. The COVID-19

virus (SARS-CoV-2) is a non-living being: can we talk about the impact (agency) of COVID-19 on mathematics education and on the world? Engelbrecht et al. (2020, p.838)

This paper will deal with the questions from this excerpt in the following sense: I will discuss how new trends of mathematics education may arise or change with the ongoing crisis, and I will draft responses to some of these questions. Trends in mathematics education can be understood as a response, an answer, to some problem, as suggested by D'Ambrosio and Borba (2010). A working group, or a conference on a given trend within mathematics education, emerges as a response to new demands. I will use the theoretical construct of humans-with-media to connect the COVID-19 crisis to three different trends: the use of digital technology, philosophy of mathematics education, and critical mathematics education. In the context of the trend of digital technology, I will discuss the possibilities and drawbacks of having more and more online education, as well as the new demand for this trend. In doing so, I will revisit the notion of humans-with-media and its perspective of collective knowledge production involving humans and non-human actors such as computers and SARS-CoV-2. This will put new issues on the agenda for philosophy of mathematics education, focusing on the agency of “things” and humans’ relation to this virus thing. Finally, I will give a brief history of the trend of critical mathematics education, and I will raise an agenda provoked by COVID-19 for these three trends in mathematics education. I believe that these discussions may be important for us to understand the moment we are living in, beyond mathematics education itself. They can also help to set an agenda of research and action in the classroom for those interested in these trends and their connection to the pandemic.

## 2. Digital Technology and Mathematics Education

Taking into consideration the notion of trends, presented above, the trend that studies the link of mathematics education and “new technologies”—informatics, communication, and information digital technology, and alike—has been present in conferences for more than 30 years. At ERME2 and SBEM3 (Borba, 2018), at ICMEs (Menghini et al., 2008), and at PME4, there are always working groups, discussion groups, and panels on the subject, because, as authors such as Jim Kaput (1991, 1992, 1998) have pointed out, we need to understand how to use computers in

mathematics education. Borba et al. (2016) prepared a survey that was presented at ICME-13 and put forward four phases for the use of digital technology in mathematics education. The four phases themselves show the strength and the length of this movement, which has involved many researchers, teachers, and students.

The first two phases, symbolized, respectively, by Logo and by curriculum-topic software (e.g., Cabri-Géomètre), are not so important for the discussion in this paper, as the Internet became the big star during the pandemic. The third phase of the use of digital technology was characterized by the emergence of the Internet and online courses. This phenomenon became important around the turn of the century, depending on the country. Some so-called developed countries saw the Internet become popular in the mid-1990s and in some other countries, like Brazil, very early this century. Brazil was one of the first countries to start online courses at the graduate level, at a time when other countries were very protective of their face-to-face education.

The current fourth phase is characterized by the arrival of fast Internet, which reshaped the possibilities of online education. As this phase has developed, Engelbrecht et al. (2020) have pointed out that different forms of blended learning are important, in particular for teacher education. The term “hybrid” has become more important to express the combination of face-to-face mathematics education and online education:

A wide array of media and technology is available to create new hybrid forms of teaching. The integration of technology enables educators to create learning experiences that actively and meaningfully pull students into course content. “This technology may form thinking collectives (Lévy, 1993) with teachers that can break the walls of the regular “cubic” classroom that is associated with lecturing.” (Engelbrecht et al., 2020, p.838)

If we consider a trend as an effort to find answers to a given issue, COVID-19 has pushed forward the agenda of the digital technology trend in mathematics education. With the need for social isolation, it became necessary to offer education to children and undergraduates at home. In most of the world, the first semester of education in 2020 was suspended or went online. Many are now discussing different kinds of hybrid education as health conditions allow students and teachers to go back to school and universities. But although we have plenty of research on implementing

education online on undergraduate education (Engelbrecht & Harding, 2002, 2004, 2005), this is not the case for education for children. In the survey articles mentioned above, and in conference working groups, hardly any research has been presented on online education for children. As this theme develops, (mathematics) education will have to deal with structural issues, such as the participation of parents or responsible others in education.

In Brazil, newspapers say that teachers are “going crazy” with demands from students coming from WhatsApp and other social networks, as students and parents in their home cannot deal with school tasks. Grading is another problem: can we grade students so young online? Is help from parents allowed? This type of question has not yet been researched. In Brazil, some research groups such as GPIMEM5 are trying to document what is happening in some state systems as a first step for research and understanding of online education for children. In the state of São Paulo, a new app, CMSP6, was created in less than 30 days for 200 thousand teachers and 3.5 million students to somehow have access to education. The app operates in conjunction with two preexisting TV channels, one operated by the state and another by a consortium of universities (Paz, 2020).

Teachers and administrators were able to supervise students through the app to some degree, and students were having three classes a day instead of five, as the state is trying to implement education through other platforms as well (Secretaria de Educação do Estado de São Paulo (São Paulo State Department of Education)—SEED, 2020). But this was a very complex moment: teachers had to go online without enough time to be prepared, and at the same time, they had to deal with their regular problems: São Paulo is the richest state in Brazil but pays its teachers a terribly low salary compared to other professionals, as pointed out to me in an online interview with a teacher who preferred to stay anonymous. Underpaid teachers now have to deal with students 24 h a day, 7 days a week, which includes dealing with students’ “personal” problems—including problems associated with the chronic social inequality in Brazil. Teachers with low salaries are not likely to have the best mobile phones, laptops, or Internet plans. Teachers who may teach fifty 50-min classes a week may deal with hundreds of students. It is likely that such problems are occurring in other countries as well, as differences between the “haves” and “have-nots” exist throughout the world, and are amplified by COVID-19, as described by the historian Walter Scheidel (Canzian,

2020).

Crisis is also a chance for change: teachers who teach 50 classes per week will not have time to learn to use digital technology for teaching. With many states and city educational systems forced to go online because of the pandemic crisis, the argument to use technology is very strong. It is likely that we will have a lot of research associated with this new reality. For the purposes of this article, I was not able to collect data systematically, but informal reports from teachers suggest that the reality of teaching young teenagers and children online will have to be investigated. As mentioned before, there is hardly any research on online education associated with levels below high school, which can be verified in many survey papers related to the theme (Engelbrecht et al., 2020). But the focus cannot only be on teachers. How do children experience this version of home schooling? There are also many jokes on social networks about parents losing control as they become home-teachers at the same time as they had to implement the home-office, so the role of parents in online mathematics education may be another area for research. Involvement of parents in mathematics education has been a theme of some research, including involvement associated with the use of digital technology (Ford, 2015; Wilson, 2013). However, this was in informal or blended settings, such as festivals (Domingues, 2020). Now we have new challenges, including to report and discuss how online assessment was developed (or not developed). Inviting students to produce mathematical videos was a research project developed before the pandemic. Having students expressing mathematical knowledge with videos, or doing research with videos, was not a solid trend in the literature. However, video production may be an alternative for education during and after the pandemic. Instead of focusing on test results, we can have students producing videos online to express what they have learned in conditions such as the pandemic. Videos can be produced collectively, with help of parents, friends, and different media. Differences in resources, including degree of parental aid received, can be considered by teachers and school systems in a “non-ranking” type of assessment.

Production of digital mathematical videos by students and teachers is growing in Brazil, and with the onset of the pandemic, an online “library” with more than 600 videos has been used as a resource for teachers and students in their classes and as inspiration for the kind of task students and teacher may produce. Moreover, issues that have been the subject of previous

research may gain new life: in a recent review paper (Engelbrecht et al., 2020), it became clear that different technologies used in a class, from the blackboard to the most modern mobile phone, are not necessarily only mediators but also actors. This is an epistemological issue, and it is part of a trend that has been discussed within the psychology of mathematics education and the philosophy of mathematics education.

### **3. Philosophy of Mathematics Education and Agency in the Notion of Humans-with-media**

“Why do we have education? What are the relations between education and society? How do we know?” These are the basic questions of philosophy of education. For more than 20 years, there have been working groups on the philosophy of mathematics education (Bicudo & Garnica, 2001). “How do we learn?” is connected to “How do we know?” and thus questions regarding epistemology, the theory of knowing, have also been debated by psychology of mathematics education discussion groups. Both domains of research may be seen as trends, as they seek foundations for mathematics education, and they discuss how mathematics education is articulated in the classroom, the research that is developed about it, and its “return” to practical settings: settings, like the classroom, which for many months have been on hold by the coronavirus pandemic. Several authors have discussed classrooms and schools and the artifacts produced there. For example, Villarreal and Borba (2010) have shown how mathematics is produced by collectives of humans-with-artifacts throughout the history of mathematics.

D'Ambrosio and Borba (2010), besides conceptualizing a “trend” as a response to a given problem, have argued that trends are intertwined, using the metaphor of a tapestry. It is unsurprising, then, that the discussion about who is the agent of knowledge is discussed in more than one trend: in digital technology working groups and in philosophy of mathematics education and psychology of mathematics education discussion groups or conferences. Different mathematics education authors (e.g., Faggiano et al., 2017) have claimed that computers, for instance, have agency. Inspired by the work of Lévy (1993) and on the phenomenological approach that humans are “being-with-others,” the notion of humans-with-media has been developed over the course of many years. The notion of reciprocal modeling was the first step (Borba, 1993). My early work on this showed not only that different media shape humans (an idea shared with



many) but also gave some empirical evidence of how humans shape technology, specifically a piece of software about functions. Being part of the design software team and a mathematics educator developing research, I could see this “collaboration” between, on the one hand, a piece of software— full of the ideas of a multidisciplinary team, presented at meetings of developers, mathematics educators, teachers, and so on—and, on the other hand, how high school students would interact with the software (and with me, a teacher-researcher). A high school student, for instance, was influenced by what I said and by the design of the piece of software Function Probe (Confrey, 1991), and he also shaped the piece of software in ways that were not predicted by the multidisciplinary team that had developed the software. This student did not use the commands the design team had created but used the size of the computer screen and other measuring artifacts to coordinate algebra and graphs. Borba and Villarreal (2005) synthesized how the notion of humans-with-media could be understood based on the work of Lévy (1993), Lave (1988), and Tikhomirov (1981). This led to the notion that knowing was not social solely in the sense that it involves more than one person, but that it also involves things.

The notion of humans-with-media was proposed to emphasize that production of knowledge is a result of a collective of humans and things. From Tikhomirov and Lave came the idea that knowing was goal oriented and that values were involved. Later, in Borba (2012), discussions about the values, emotions, and media involved in knowing mathematics with GeoGebra (or whatever software was available) were extended to the idea that media and technology themselves change notions of what humans are. Media are therefore constitutive not only of what we know but also of what we are. Kaptelinin and Nardi (2006) also analyzed the idea of extending agency to non-humans. These authors compared the capacities to produce effects, act, and fulfill intentions of different agents: things (natural), things (cultural), non-human living beings (natural), non-human living beings (cultural), and human beings as social entities.

Agency, therefore, should not be seen as binary, as either present or absent, but having different levels. I see this notion of agency as a “fuzzy” one, as in fuzzy mathematics, in which we may have degrees of agency. In such a mathematics, for instance, my jeans are not just blue or not (zero or one), but they are, for instance, 0.6 blue. Kaptelinin and Nardi (2006) suggest three dimensions of agency: based on necessity (action is

taken based on biological and cultural reasons), delegated (things or living beings act as the perceived intentions that are delegated by other humans and things), and conditional (actions of things or people which result in unintended effects).

The notion of humans-with-media, which is consistent with a more complex view of agency, has been challenged, in many instances, by arguments that want to preserve the power of a human as the center of any action. In these views, intentionality and action come from somewhere that is not social. Much of mathematics education, cognitivist or not, is based on such a “one-knower” view. From such a perspective, the agent of knowing is a single person, or collective of humans, even though most researchers would recognize the influence of artifacts, environment, and social cultural factors.

The notion that both humans and non-humans have agency is part of an effort to model artifacts—in particular, pieces of software, hardware, and the Internet of Things (i.e., things that are connected to the Internet)—as the historical, social, and cultural factors in the collective that produces knowledge. It stresses a view that knowledge is produced (both from a philosophical and a psychological perspective) by humans-with-artifacts. With a perspective in which things have agency, artifacts are labeled media as they are thought to communicate. This argument was more easily applied for technologies of intelligence (Lévy, 1993): humans with-graphing-calculators were easier to accept as having agency than humans-with-libraries or humans-with-classrooms.

Regardless of whether readers value online mathematics education or not, they may at some point use their memory of a regular classroom to claim that face-to-face interaction is fundamental to any learning that occurs in mathematics education. Alternatively, one may use the notion of a “distributed classroom”: an office for one student, the bedroom for another, and some kind of computer center for others. But everyone would recognize that classrooms are changing. We have described this as a classroom in movement (Borba et al., 2014).

What constitutes the unit of knowing is an endless, philosophical discussion: is it a single person? Is it social because it involves more than one person? Is it social because it has a goal, and it involves humans and non-human actors? It is an endless discussion, like most philosophical discussions. However, it seems that the emergence of SARS-CoV-2 gives strength to one perspective on knowing because, according to authors

such as Racaniello (2004, p.1), “Viruses are not living things. Viruses are complicated assemblies of molecules, including proteins, nucleic acids, lipids, and carbohydrates, but on their own they can do nothing until they enter a living cell. Without cells, viruses would not be able to multiply. Therefore, viruses are not living things.” Yet despite being non-living, the virus has dramatically changed the way humans live. Viruses are closely connected to us: they cannot exist for long apart from living things, like humans, who have cells; the symptoms of COVID-19 arise under certain conditions when the virus is inside human cells. We can say that the virus has agency in the sense that it has changed the way we have to do things. This analogy helps us to understand how certain things are much more likely to happen if certain actors are present. To use the metaphor of the virus, software also needs humans to “survive.” Software, and later on the Internet, has changed the environment of educational settings, in a similar way to how SARSCoV-2 has suddenly turned children’s bedrooms into classrooms.

Latour (2020a, b), another inspiration for the notion of humans-with-media, presents his concern with the virus crisis in a way that relates to the discussion in this paper:

But there is another reason why the figure of the “war against the virus” is so unjustified: in the health crisis, it may be true that humans as a whole are “fighting” against viruses — even if they have no interest in us and go their way from throat to throat killing us without meaning to. The situation is tragically reversed in ecological change: this time, the pathogen whose terrible virulence has changed the living conditions of all the inhabitants of the planet is not the virus at all, it is humanity! But this does not apply to all humans, just those who make war on us without declaring war on us. For this war, the national state is as ill-prepared, as badly calibrated, as badly designed as possible because the battle fronts are multiple and cross each one of us. It is in this sense that the “general mobilization” against the virus does not prove in any way that we will be ready for the next one. It is not only the military that is always one war behind. (Latour, 2020a, b, para.8)

Latour, without saying so explicitly, foregrounds the agency of this virus: SARS-CoV-2 spreads through humans to survive and reproduce, and this action provokes reaction—agency—from humans. Of course, every comparison or metaphor has its limits. But the

coronavirus has transformed our lives—we still do not know for how long—in a dramatic way. Computers—now represented by mobile phones, which are much more potent computers than the ones used at the end of the last century by the minority of students who had access to them—have changed the way we can experience mathematics, in particular the way we can “experiment” with mathematics. The Internet has become a community, an agent, and an artifact. Videos that are produced and shared by students with digital technology soon themselves become a part of new collectives of humans and media that are involved in producing knowledge. Souto and Borba (Souto & Borba, 2016, 2018) have discussed how the notion of humans-with-media, which had its origins in activity theory (Tikhomirov, 1981), is now about to change the third generation of activity theory, breaking the rigidity of the triangles espoused by Engeström (2002) and Sannino and Engeström (2018).

This version of the humans-with-media construction has been called system-of-humans-with-media (Souto & Borba, 2018) to emphasize even more the notion that the collective of humans and non-humans is goal oriented and embedded in a community that has rules. Considering media as agent has made it possible to think of the rigid triangles of the third generation of activity theory as dancing triangles, or as a GIF, in which the Internet, for instance, could be jumping from the instrument corner to the subject corner and/or to the community corner.

It is hard to know, as mentioned before, where the developments of the current health crisis will take us, but it seems that thinking about agency of non-living things as discussed in this section will be part of it. Questioning what the definition of “living things” is may be another consequence, which, of course, goes beyond what has been called the psychology of mathematics education or philosophy of mathematics education. But it will be relevant to some questions that perhaps were put aside or never asked before, questions such as: What are the specific roles of spaces/artifacts such as the classroom, face-to-face environments made for the intense use of Internet in education, and the “online classroom?” If the pandemic lasts even longer, what do we really mean by “face-to-face?” What does it mean to discuss affection in mathematics education without physical contact (e.g., hand shaking, hugging, kissing the cheek), so important in many parts of the world? The whole discussion about humans-with-media may gain a new dimension, as suggested in this section, related to some of the basic questions of philosophy of

(mathematics) education. The pandemic foregrounds the role of home and the role of different parents and different social conditions in collectives that construct knowledge, in activity systems that produce knowledge. The idea of seeing fuzzy agency in non-humans should be developed further to include not only good access to internet, but to housing, which is a site of brutal inequality in Brazil and elsewhere. This famous photo illustrates the extent of inequality in Brazil, which, from the educational point of view, suggests that different housing may have different agency in constructions of knowledge, in particular in situations such as the one we lived during the pandemic. Housing matters in knowledge construction. Trying to solve a mathematics problem in a crowded house in a slum is very different than doing so in a spacious, luxurious apartment with a veranda.

In this sense, SARS-CoV-2 has pushed homes into the center of a collective that produces knowledge. Once again, we ask all the basic questions of the philosophy of mathematics education and psychology of mathematics education. What is the role of mathematics education? What is the role of the different education of parents in mathematics education? What is the role of non-living things, such as viruses, pieces of software, and homes, in the way we know and learn mathematics? A question that may be more critical is: What is the role of mathematics education for resisting inequality in the world?

#### 4. Critical Mathematics Education and Coronavirus

The trend of critical mathematics education (CME) responds to the main problem of social inequality in (mathematics) education and struggles against the view that mathematics is a branch of science that is separate from social, cultural, and political issues. CME's role in the community of mathematics education is to remind us all about social inequality and other types of inequalities. CME may be said to have been officially born in 1990, in a meeting at the Cornell University in the USA (Powell, 2012; Torisu, 2017). There, the Critical Mathematics Educators Group was founded, with several members<sup>7</sup>, focusing on the key phrase "social justice." Powell (2012) reports on how at ICME 6, in Budapest, Hungary, there was a meeting of researchers and how after the Cornell meeting, the group began to meet regularly, starting at ICME 7, in Quebec, Canada.

Present at the Quebec meeting was Skovsmose (1994), who also wrote about the development of

critical mathematics education in Europe. Skovsmose shows the connection of this branch of CME in Europe to the Frankfurt School of Critical Education, one of the main representatives of which was Adorno, whose main issue was seeking an education that would prevent Nazism from occurring again. Today, critical mathematics education is more than important, in a moment in which countries such as the USA, Brazil, and Italy have far right or fascist leaders, who have praised some of the fascist leaders of the twentieth century.

In the Cornell meeting, issues of social inequality, the role of mathematics in society, the ideology of certainty, and research methodologies appropriate to CME were presented (Borba, 1991; Borba & Skovsmose, 1996; Skovsmose & Borba, 2004). Since the 1990s, in Africa, authors such as Paulus Gerdes, from Mozambique, developed curricula and research about African traditions in mathematics and how to incorporate them into mathematics education (Gerdes, 2010; Torisu, 2017).

Development of curricula and pedagogical perspectives that highlight social inequality, gender and racial inequity, and the ideology of certainty was the initial focus of CME. More recently, environmental issues, and issues that were treated in other trends (e.g., mathematics education to the deaf or the blind), were brought into the agenda of CME. In sum, CME is a trend that shows that education is not neutral: it can promote equality or inequality. There are indicators already from Forbes that social inequality is growing during this pandemic: the billionaires are becoming even richer (Gavioli, 2020). The owners of Facebook and Amazon are among them! There is no need to be a mathematician to understand that this concentration of wealth upward means that the rest of the people have less. The owners of tech companies stand to gain as people move more and more online: their companies run online social networks, run online shopping services, and store digital data in online systems worldwide.

As I have already illustrated, social inequality is also growing in schools. As most schools and universities suspend face-to-face classes and go online one way or another, the issue of access has been a barrier to some and a trampoline to even more social inequality. Some universities in Brazil even opted not to resume education online because of inequitable access; but of course, as the university is not the only source of knowledge, online education also may have caused more social inequality. Here is an example from (mathematics) education in Brazil of a Catholic school located on the outskirts of a midtown city in the state of

Sao Paulo: the school does not charge tuition for students, as parents do not earn enough income to feed their families; violence is also part of the daily experiences of these children. Teachers are paid above average (considering Brazilian standards), and from interviews with them, it is easy to see their engagement in fighting social inequality. Classes were first suspended in mid-March 2020 and resumed online afterwards, at different moments of April, depending on the school. Two teachers, Luiz Felipe Trovão (mathematics educator) and Karla Cristina Stropa Goulart (science educator), who were asked to answer an open question about their experience with teaching during the pandemic, reported how hard it was to communicate with students. Most students did not have access to the Internet. When they had access, they did not have the money to buy credits to operate the Internet<sup>8</sup>. The school tried to overcome this problem by providing chips with credits or sending printed didactical material to the children. But with less interaction with teachers, and without an environment to study in poor homes, through no fault of the teachers or the school, very little mathematics education or science education occurred. Trovão said that it is almost impossible to teach geometry online without proper interaction: homes, Internet access, etc.

The billionaires are becoming even richer; the poor are having even more difficulty accessing mathematics education: this may foreground the need that children will have, after the pandemic, to understand what happened. Mathematics educators may have to explore some tough topics: exponential functions to explain the spread of the coronavirus and how the richest grew even richer. Mathematics will not be enough, but a new agenda will be generated. Freire's (1968) work about the pedagogy of the oppressed will be even more important. Putting together the agenda for the three trends, one should consider, for example, the role that home, as a physical and emotional "thing," has in the pandemic school. We have collectives of home-parents-internet-student-teacher as the minimal unit of the collective agent who produces knowledge. Home and parents, things, and humans, have added more to social inequality and to discussions about how to use digital technology in mathematics education.

Humans-with-media, seen as an activity system, provides a dynamic epistemological view that we can use to understand the different social aspects (in the micro- and macrolevels) of the research of digital technology. Simultaneously, in acknowledging agency in a wide variety of things, not only computers, but it

will also be possible to structurally show social inequality: homes equipped differently cannot be assessed the same way. Children will suffer even more injustice than they suffer in school, if differences in Internet access, the comfort of home, etc., are not considered in assessment and teaching. Research under this frame, in digital technology, critical mathematics education, assessment, ethnomathematics, and other trends, may help to bring light to more epistemological discussion that is not value-free.

## 5. Discussion and Conclusion

Most of mathematics education is supported by empirical papers. In the 1970s, most research was quantitative, and data was used to "prove" that a given method of teaching was better than another. Empirical data had the same role it plays to this day in a good part of what is considered science: there were control groups and experimental groups, and the methodology was based on (or reduced to) statistical treatment and conclusions. Later last century, and earlier this century, qualitative research has swung the pendulum in another direction. Qualitative research sees data as a voice, as a complement that should be added to other evidence in order to make ("prove") a point (Borba et al., 2018). Truth was assumed to be explicitly contingent and subject to change long before the COVID-19 pandemic brought so many instabilities to our beliefs. As arguments grew apart from data, a wide set of reactions, including some from powerful funding agencies, emerged. For example, there were funding agencies that require quantitative data in a project. Now the notion of mixed methods is prevalent, even though it is not clear what the role of the data or the view of "truth" is in much of the research published.

Essays such as this paper serve the purpose of discussing ideas and presenting bases for research papers, so that we can know (in the different directions briefly presented above) about mathematics education, in the different epistemological positions that characterize our community. In this sense, this paper is a result of a reflection on how three trends could have their agendas transformed by SARS-CoV-2. Of course, other trends, such as ethnomathematics or early-grades mathematics education, will also be affected. The issues raised throughout this paper should be transformed by readers and should themselves become the objects of research. In this paper, I choose to deal with digital technology, philosophy of mathematics education, and critical mathematics education because the pandemic seems to have played a significant role in the changes of

the agendas of these three trends. It seems important to raise new issues in these trends.

Digital technology is now a theme of concern (or research) for everyone (Engelbrecht et al., 2020a, b). The amplification of the starkness of inequality under the pandemic cannot be ignored (except for those who believe that the Earth is flat, and that hydroxychloroquine is a miracle cure for COVID-19), and the rise of the home office, associated with home schooling, confinement, and lockdown, may help many to think about philosophical issues regarding the role of “place” in knowing/learning and notions such as humans-with-media.

In the paragraphs above, I have pointed at my choices in identifying important trends. Why did I say “I” instead of “we,” which would refer to a collective of humans-with-media? It is a good question, and a tentative answer, in another domain of discussion (qualitative research and its influence in the classroom), was given in Borba et al. (2018). The authorship of a paper or a book may be individual, but it is a result of a collective endeavor of “endless” humans with-media. This paper has one author, but it involved the active participation of one doctoral student (Juliana Çar Stal), three teachers who lent me their speech (Karla Cristina Stropa Goullart, Luiz Felipe Trovão, and one who wanted to remain anonymous), the reviewers, the editors of this special issue, members of the research group I belong to, the more than 100 members of the graduate program in mathematics education at UNESP10, Rio Claro, friends, the computer, the word processor, the home, the office, and, of course, the pandemic, COVID19. We hope we can discuss this at the next ICME and that it does take place in 2021!

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# How to Spread the Voice of China through College English Education: Inspiration from 3P Teaching Model

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**Abstract:** In the political and economic context of One Belt One Road, it is recommended that China's College English education should focus on telling Chinese stories, spreading the voice of China, and building a bridge for cultural communication between China and foreign countries. This paper argues that integrating traditional Chinese culture and socialist core values into College English education is an effective way to spread the voice of China. It further explores the inspiration for College English education to spread the voice of China based on the 3P teaching model, which is a conceptual framework for the rational analysis of university teaching methods based on three important nodes in the teaching process, namely premise, process, and product.

**Keywords:** One Belt One Road, 3P teaching model, voice of China, college English education

## 1. Introduction

One Belt One Road (hereafter abbreviated as B&R) is the abbreviation of the Silk Road Economic Belt and the 21st Century Maritime Silk Road. In September and October 2013, China's President Xi Jinping proposed the cooperation proposal for building the new Silk Road Economic Belt and the 21st Century Maritime Silk Road (Propaganda Department of the CPC Central Committee, 2016). It means that China and relevant countries borrow the historical symbols of the ancient Silk Road, hold high the banner of peaceful development, actively develop economic cooperation with countries along the line of B&R, and jointly build a community of interests, a community of destiny, and a community of responsibility with mutual political trust, economic integration, and cultural tolerance. Developing B&R cultural exchange will harmony but not sameness. It will be important to promote the whole nation's external communication, promote the international dissemination of Chinese culture and build the community of human destiny. Under the new situation one should grasp B&R, the opportunity to realize the external communication of Chinese culture, and more effectively realize the Chinese culture going out (Guo & Liu, 2019).

## 2. B&R and Spreading the Voice of China in

### College English Education

#### 2.1 B&R construction and cultural exchanges

Promoting the B&R construction is a great strategic vision put forward by the Chinese central government and a major strategic decision for China to take the initiative to tackle the profound changes in the global form and to coordinate the two overall situations at home and abroad. President Xi (Propaganda Department of the CPC Central Committee, 2016) pointed out that it is difficult for B&R without cultural support to last for a long time. B&R strategy is not only an economic exchange, but also an important line of cultural exchange. In order to successfully B&R strategy, we should insist on the culture ahead and set up a high degree of consciousness of culture leading the economy. We should not only play a positive role in promoting modern culture, but also integrate China's fine traditional culture into the B&R construction, strive to promote the inheritance and innovation of Chinese excellent traditional culture, and deepen exchanges and cooperation with the countries along the line. So as to achieve common development. In the nineteen major reports of the party, General Secretary Xi Jinping (Propaganda Department of the CPC Central Committee, 2016) emphasized: "to promote the construction of international communication capacity, to tell the story of China well, to show the reality, three-dimensional and comprehensive China, and to enhance

the national cultural soft power." We should do a good job in external publicity, innovate external publicity methods, strive to create new concepts, new categories and new expressions that integrate China and foreign countries, tell Chinese stories well and spread the Chinese voice well. "(Propaganda Department of the CPC Central Committee, 2016).

## **2.2 English language is an important carrier of cultural communication**

According to Guo and Liu (2019) there is a shortcut to tell a good Chinese story, let the outside world know China better and understand China, and spread Chinese traditional culture through English, the world's common language. B&R initiative has further promoted the process of China's cultural transmission and provided an essential basis for promoting China's culture and displaying China's cultural charm. B&R is a time discourse integrating the political, economic, and cultural fields. Language is the main tool for cultural exchange, and an important carrier of cultural heritage and development. Under the background of all the other areas, language teaching has become an important way of national cultural output, image output and ideological output, and English as a global language, is responsible for promoting economic exchanges and increasing international exchanges. It plays an important role in strengthening cultural interaction. For China in B&R, the Department of higher education, Ministry of education (2017) addresses that College English education should serve the overall situation of "going out" and build a bridge for cultural communication between China and foreign countries. Under the dual background one is B&R and the other is "going out", College English teachers have trained highly practical talents with high quality, high ability and high level, and promoted the deep integration of culture education and language education and explored the important mission of integrating Chinese culture into College English classroom.

## **3. Using the Content of College English Education to Spread the Voice of China**

### **3.1. Chinese traditional culture**

In the context of the B&R, there are new opportunities for cultural exchange and integration between China's traditional culture and the countries along the Belt and Road. Since the 18th Party Congress, General Secretary Xi Jinping (Propaganda Department of the CPC Central Committee, 2016) has repeatedly emphasized that the historical influence and importance of traditional Chinese culture at major conferences. He

(Propaganda Department of the CPC Central Committee, 2016) pointed out that Chinese traditional culture has a long history, broad and profound, is the most fundamental spiritual pillar of the Chinese nation and represents the unique spiritual symbol of the Chinese nation. The value pursuit of benevolence, people-oriented, honesty, justice, harmony, and harmony in Chinese excellent traditional culture is not only conducive to promoting the harmonious coexistence between countries and people, but also has great practical significance for the development of communication in the contemporary world. In the context of "One Belt One Road", promoting Chinese culture "going out" can, on the one hand, make foreign people touch the pulse of Chinese culture and perceive the charm of Chinese culture; on the other hand, promoting Chinese culture "going out" can also make the correct image of China in the world continuously established and shine, thus promoting the economic interaction between China and the countries along the Silk Road, and also making China's cultural exchanges gradually strengthened.

### **3.2. The core values of Chinese socialism**

In the report of the 18th National Congress of the Communist Party of China (Propaganda Department of the CPC Central Committee, 2016), the main idea of the discourse of socialist core values has been systematically and clearly expressed in the form of "three advocations" for the first time. Subsequently, in December 2013, the general office of the CPC Central Committee issued the opinions on the cultivation and practice of socialist core values, which further defined the basic content of socialist values as "prosperity, democracy, civilization, harmony, freedom, equality, justice, rule of law, patriotic, dedicated, honest and friendly".

Today's culture shows a diversified development pattern, and the internal attractiveness of a country's culture is through the identification of core values. China not only needs to inherit the ideas and moral resources of the excellent traditional Chinese culture, but also constantly promote the integration and convergence of the cultural ideas of all countries in the world, showing the spirit of appeal and the value of the times. The socialist core values are the spiritual core of the socialist core value system and the embodiment of the most advanced national culture and spirit of Chinese values. Chinese values in the countries along the Belt and Road are not only to transmit "our values", but also to let the world understand China more objectively through the exchange of values and ideas, so that



Chinese values can become the power source of the Belt and Road, and gradually realize the harmonious coexistence of Chinese values and the values of the world (Sun, 2018).

The College English teaching guide issued by the Ministry of education (Department of higher education, Ministry of education, 2017). proposes that the socialist core values should be effectively integrated into the College English teaching content. Some studies have pointed out that the discipline integration model is better than the independent discipline model. Due to the dynamic characteristics of language education, a foreign language teaching classroom is also known as a natural place for moral education (Shaaban, 2005). Halliday (1994), a scholar of systemic functional linguistics, believes that language can not only reflect reality, but also construct reality. College Students learning English is not only for a more direct understanding of the most cutting-edge development of various disciplines and learning to understand other excellent cultures and civilizations, but also for telling Chinese stories in English in this new era, enhancing China's international image, effectively spreading Chinese culture and enhancing China's international influence College English, as a window course of general education courses in Colleges and universities across the country, has the characteristics of wide coverage, large span and long class hours. In the process of learning, college students have the most extensive and intense communication and collision with western politics, culture, and ideas. How to integrate values education into all aspects of course teaching? This is worthy of all college English teachers to think and explore.

#### **4、 The Practice of Spreading the Voice of China in College English Teaching**

"3P Teaching Model" (See Appendix 1) is a conceptual framework for the rational analysis of university teaching methods based on constructivism. The "3P" refers to the three important nodes in the teaching process, namely, premise, process, and product. This concept was first put forward by Dunkin and Biddle (1974). Australian educational psychologist Biggs and his colleagues have conducted 50 years of in-depth research and practice on it, and the "3P teaching model" has gradually matured (Biggs & Tang, 2007).

The 3P teaching model is a cycle mode: the former link acts on the latter link, and the result of the latter link, in turn, affects the process of the former link. Moreover, each factor in each link interacts with other factors and

directly affects the results. Starting from the "premise" link, 3P teaching model emphasizes that students should be regarded as the main body in the teaching process, and strengthen students' subjectivity, that is, students' autonomy, initiative, and creativity in learning. In this way, the traditional one-way teaching method is transcended, and the overall transformation of the teaching mode is realized, from teachers "teaching" to students' subjective initiative "learning". The subjective initiative learning, and teaching are closely related; good teaching must help students get high quality learning; students' learning must be the center of teaching activities ( Prosser & Trigwell, 1999). Through learning change and produce meaning, multi-dimensional evaluations are used to evaluate students; learning effect, and immediate feedback is used to facilitate students to modify the learning process.

The aim of the 3P teaching method is to learn and use language, integrate the process of various activities so that learners can achieve the purpose of communication. This paper attempts to use Biggs's "3P Teaching Model" for reference to design the teaching of Chinese cultural elements contained in the professional knowledge of College English courses. With the help of a case study, this paper expounds on the enlightenment of the 3P teaching model on the integration of College English courses into Chinese culture.

##### **4.1 The enlightenment of premise of 3P**

The premise is at the front of the learning sequence. The premise factors include two parts: Students' main factors (a priori knowledge, ability, preferred learning style, etc.) and teaching situations (objectives, evaluation, atmosphere, teaching, etc.). In the whole 3P teaching model, teachers' "teaching" is integrated into students' "learning" and jointly become the "premise" of students' learning, Teachers' teaching is only a way to guide and assist students' learning, not the center of students' learning. Students' factors and teaching situation factors jointly determine the methods adopted by students for a task, which in turn determines the results.

First, the enlightenment of the premise of 3P improves the ability of teachers. Though B&R, the teacher, the organizer, and the manager of College English education brings opportunities for the spread of the voice of China. College English teachers should pay more attention to the cultivation of Chinese and Western cultural values while cultivating students' English learning skills, so that students can not only learn and understand the essence of western culture, but also pay attention to the cultivation of profound Chinese cultural

heritage, strengthen their sense of identity with Chinese culture, and then produce their national pride. In One Belt One Road is self-confidently and fully effective in expressing China's culture in English.

Second, the enlightenment of the premise of 3P respect students' principal position. Each student has their ability, personality, and motivation. In the classroom design, College English teachers can try to give up one-way propaganda and fully mobilize the enthusiasm of students' participation. Instead, teachers design the content related to the dissemination of Chinese culture as learning tasks or activities for students to participate in and let students complete them independently or cooperatively.

Third, the enlightenment of the premise of 3P promotes the integration of Chinese culture into teaching. The Chinese traditional culture is broad and profound. In the compilation of teaching materials, it will not only reflect the excellent Chinese traditional culture but also present the Chinese culture and Chinese stories of China's development in the new era, which will be flexibly embedded in the College English classroom. For example, when setting up "English newspaper reading", teachers can break the traditional feature of using British and American newspapers for extensive reading. They can introduce English news, hot topics, and audio-visual materials of Chinese themes into the audio-visual and oral classroom, such as China Daily and global times, which fully embody the core socialist values, guide students to understand how China spreads the voice of China to the international mainstream society.

Case 1: During novel coronavirus pneumonia, Xi Jinping, President of the Republic of China, awarded the "Republic Medal" to Zhong Nan Shan to honor the National Medal of honor for Zhang Boli, Zhang Dingyu, and Chen Wei. Great doctors are sincere and write great love. They have safeguarded people's lives with exquisite medical skills and selfless dedication. Teachers can select CGTN (China Global Television Network) Related videos and English texts to introduce them into the classroom so that students can talk about their self-feelings during the anti-epidemic period, and lead students to experience the great spirit and home feelings of anti-epidemic heroes.

Case 2: the BBC's documentary "Chinese New Year" introduces in detail the traditional customs of the Chinese Spring Festival, including making dumplings, pasting Spring Festival couplets, watching Spring Festival Gala, dragon and lion dance, fireworks, and praying. The video also introduces many traditional

Chinese cultures that Chinese people don't know much about at ordinary times, such as traditional folk activities such as beating trees and flowers, winter fishing in Chagan Lake, and the brewing process in Luzhou Laojiao. Teachers can extract video clips, play, and assign learning tasks in class so that students can not only learn authentic English expression but also deeply learn and understand this excellent traditional Chinese culture.

#### 4.2 The Enlightenment of process of 3P

The teaching process of case teaching under the guidance of 3P model is characterized by deep-seated and high achievement teaching. It belongs to a mode with high degree of learning engagement, and more emphasis is put on the reasonable distribution of the roles of teachers and students and more extensive participation of students. Therefore, in College English teaching, we should improve students' participation, reasonably allocate the roles of teachers and students, constantly standardize the teaching process, show their own image, tell Chinese stories and make Chinese voice in College English teaching with Chinese culture, stimulate students' patriotic feelings and improve students' cross-cultural communication ability.

Case study: teaching design of Mona Lisa in New Generation College English

The famous painting "Mona Lisa" and Chinese landscape painting as well as a series of traditional Chinese works of art behind the Chinese and Western Aesthetics (unit 2) will be displayed in the Louvre in France. As a Chinese volunteer, you will write a detailed introduction to an exhibit. These introductions will form a collection for visitors to read, so that they can have a deeper understanding of the exhibits and the traditional Chinese culture. Understand Chinese art and its English expression; Flexible use of rhetorical devices and text structure in the text; Using multiple language strategies to help foreign visitors understand and appreciate Chinese art.

In this case, "one-way output" turns to "active exploration" of students, with students' curiosity and inquiry interest as learning motivation. First, teachers should play a good role as guides to create a democratic and equal classroom atmosphere, so that students can identify with their own dominant position; Actively guide students to fully display the materials prepared before class, drive other students' situational awareness, embody cross-cultural awareness in the process of knowledge exploration, contain emotional satisfaction and sense of value, enhance cultural confidence, and then realize the positive stimulation and guidance of

teaching design on students' deep learning methods.

### 4.3 The Enlightenment of Product of 3P

Two famous American educators Buckley and Mayor once proposed 50 practical classroom evaluation methods according to Fink's teaching goal classification system. Fink believes that there are six dimensions of teaching objectives that can lead to deep learning, namely "knowledge base, knowledge application, knowledge integration, humanity, care and learning to learn". Among them, "Humanistic Dimension" aims to detect students' new understanding of themselves and others in the process of learning, which is consistent with the teaching objectives of the voice of China. Therefore, several classroom evaluation methods for this kind of teaching objectives are worth our reference, such as group discussion, nomination, role play, etc. (Barkley & Major, 2016).

In the decryption of Mona Lisa's teaching cases, we can try to use the way of group discussion. In the classroom, we divide the students into several discussion groups. During the discussion, we make a learning evaluation form on the preparation, listening, expression, and other aspects of the group members, and make peer evaluation in the group. On the one hand, the results of the group discussion can reflect whether the students have a deep understanding of the value of Chinese culture. This evaluation helps to test students' recognition and understanding of Chinese cultural values. At the same time, it closely combines teaching activities with learning evaluation and points to the teaching goal of spreading Chinese culture in the College English curriculum, which is consistent with the principle of "consistent construction" advocated by the 3P teaching model. At the same time, the information provided in the discussion can also help teachers adjust and follow up on the next teaching arrangement.

### 5、 Conclusion

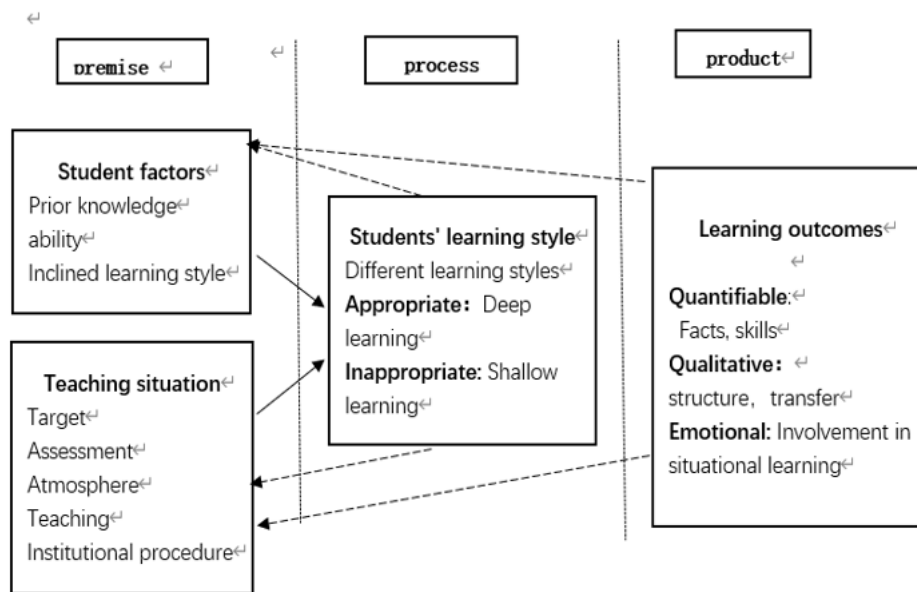
B&R initiative China's research hopes to spread China's voice in College English education through the analysis of the 3P teaching model, further promote the process of China's cultural transmission, and provide ways and means to integrate Chinese culture into the teaching process, thus enriching the teaching system of the English course for the University. B&R is to foster students' internal cultural attainments and cultivate high-quality intercultural communication talents who integrate China's culture into the B&R construction.

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### Appendix 1: 3P Teaching Model



# Dynamic Ecology in Moving Between Teacher and Teacher Educator Roles: A Study of Two Teachers

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**Abstract:** Becoming a teacher educator is commonly a one-way journey towards an academic role, where current knowledge of classroom context is progressively diminished. Research attention to the development of teacher educators is limited. This study examines the relationship between the roles of teacher and teacher educator, involving issues of identity and community. It investigated, through analysis of reflective narratives, the careers of two specialist English language educators, both working in dual roles as teacher and teacher educator, working in Sydney, Australia, and Jiangsu, China, respectively. The team of researchers collaborated in thematic interpretation of the two narratives. The study examines the shaping of teacher educator beliefs, and the impact of context on their pedagogy and sense of purpose. The analysis identifies in both narratives, a circular investment of learning, and a dynamic ecology occurring in the simultaneous roles, which the two teachers invest in both their language learners and in the pre-service teachers they are training. Considering the increasing trend to employ research academics in teacher education, the study argues for greater recognition of the educational outcomes of the teacher/ teacher educator model.

**Keywords:** Australia, China, English language educator, reflective narrative, the role of teacher

## 1. Introduction

There is increasing research attention to quality practice in teacher education, considered foundational to achieving quality learning outcomes in schools. While there is attention to teacher education curriculum content (TEMAG, 2014) and meeting mandatory national standards (AITSL, 2015; Mayer Luke & Luke, 2008) there is limited attention to the teacher educators themselves and the intersection of their identity with their delivery of that content.

The process of becoming a teacher educator often involves a transition from a role of school teacher. It is acknowledged that recent classroom experience and knowledge is an invaluable element in the role of teacher educator (Williams, Ritter & Bullock, 2012). Research has noted however the lack of induction for teacher educators, the often unguided and stressful process of acquiring the required new knowledge and skills (Williams et al, 2012), and the necessary shift in identity from school teacher to teacher educator. Further, research has most examined the trajectory as a one-way journey towards the new academic role. It is less common to examine the particular experience of the

cohort of teachers who, in various international contexts, continue to work in both roles simultaneously. There has been very limited research attention to the dynamic and circular relationship between their professional learning and practice in both contexts.

This article reports a study which critically investigated the narratives of two teachers who simultaneously occupy the roles of English language teacher and English language teacher educator, one in Jiangsu China (English as a Foreign language hereafter EFL), and one in Sydney Australia (English as an Additional Language or Dialect hereafter EALD). The study illustrates the shaping role of social context in the development of teacher educator knowledge, practice, and professional community membership. The study throws light on practice and beliefs in English language teacher education, and commonality of experience in identity development, despite the difference in contexts. The study examines how the two teacher educators construct their dual roles and dual practice, model their identity as English language teachers, and negotiate their membership of two professional communities. The study highlights the learning potential of this situation for quality practice in teacher education internationally.

Considering the trend in universities to employ research academics in teacher education roles, and to view the teacher/teacher educator as a deficit model, or as only semiacademic (Murray, 2002), the article argues for the educational value of employing greater numbers of practicing teachers in teacher educator roles.

## 2. Literature Review

This study refers its analysis to Wenger's (1998) theoretical framework of the process of identity formation within community. Wenger has described this as involving two processes: identification and negotiation of meaning. Identification is constructed from engagement (investing ourselves in our practice, as well as in relations with others), imagination (seeing our experience as part of a broader context) and alignment (connection to others when our practice is in line with a broader enterprise, involving power). Negotiation of meaning involves ownership of making meaning of experience, power processes, and, if the participant's contribution is continually denied, possible marginalization.

Identity is understood as multiple, fluid and often conflicted in nature (Hall, 1990), related to social, cultural, and political contexts (Cummins, 1996; Lave and Wenger, 2002), and negotiated through ongoing social interaction (Bucholtz & Hall, 2003).

There is recognition in different contexts globally that teacher educators are a neglected research group, for example, in the Netherlands (Willems, Stakenborg, & Veugelers, 2000), in Israel (Ben Peretz, Eilam, & Landler-Pardo, 2011) and in China (Wang, Moloney & Li, 2013). In Australia, there is inadequate acknowledgement of the cultures and contexts within which teacher educators do their work (Gore & Morrison, 2001).

Williams Ritter and Bullock's (2012) review of around sixty self-studies by beginning teacher educators concludes that becoming a teacher educator involves several complex and challenging tasks: examining beliefs and values grounded in personal biography, including those associated with being a former schoolteacher; navigating the complex social and institutional contexts in which they work; and developing a personal pedagogy of teacher education that enables construction of a new professional identity as a teacher educator. Beginner teacher educators identify strongly with their school teacher identities and rely upon their experiences in the classroom to guide them in their early work as teacher educators (see for example, Dinkelman, Margolis, & Sikkenga, 2006;

McKeon & Harrison, 2010). Beginning teacher educators' learning is essentially a social practice. Wenger (2000) argued that learning lies in the interplay between social competence and personal experience, and as such is a dynamic, two-way relationship between people and the social learning systems in which they participate.

The teacher educators in this study move, and learn, between two communities, acquiring what Wenger (1998) terms "multi-membership". By coordinating connections across communities (termed „boundary encounters“, (Wenger, 1998)), participants are able to open up possibilities for learning, and to gain new perspectives that are not apparent within one community alone. The nature of practice in these circumstances also changes, as interactions and connections enable new ways of learning and new practices to emerge, enabling identities of participation to be constructed and modes of belonging to be strengthened. Wenger (1998) argues that newcomers to a community of practice not only learn for and about themselves, but their knowledge impacts on the organization that they are entering. Williams et al (2012) similarly conclude that the potential for teacher education to be enriched by the experiences brought in by former schoolteachers is enormous.

To capture the function of societal issues in shaping teacher knowledge, qualitative interpretive modes of enquiry are important research tools (Ben-Peretz, 2011). In particular, narrative research has been recognized to be of significance in capturing language teacher development (Barkhuizen, Benson & Chik, 2013; Golombek & Johnson 2004; Harbon & Moloney, 2013). In our work situated within two different national educational communities, we have endeavored to avoid essentialization of educational schema. The next section briefly describes current issues in English language teaching in Australia and China.

## 3. Teacher Education for Australian EAL/D and Chinese EFL

In New South Wales Government schools 30.9% of students are identified as coming from a Language Background Other than English (LBOTE), with the majority living in the greater Sydney region (CESE, 2013). New Arrivals Program funds secondary school preparation for up to 55 weeks learning in an Intensive English Centre. Students then transition to secondary school and may be supported by EAL/D specialist teachers (ACARA, 2013, p. 9). The rationale, and method of EALD teaching is thus to equip students with

academic English language skills and an understanding of Australian culture.

In Australian universities, pre-service teachers may include a “specialization” in EALD teacher training in addition to their principal Key Learning Area (subject they intend to teach) within their undergraduate teaching degree. At the University of Authors 1 and 3 this involves the inclusion of units of study in Linguistics, a unit of study in EALD methodology and a short school practicum.

EFL teaching in China is in a process of change, driven by the National English Curriculum Standards (NECS hereafter; Ministry of Education PRC, 2012). The curriculum promotes intercultural language learning, the need for differentiation, and for use of language in authentic contexts. Following the NECS, there has been only limited research attention to EFL teacher education. Zheng (2015) provides research insight into the beliefs of Chinese EFL teachers and their pedagogical choices and offers a systematic framework of how teacher beliefs and innovation may be applied in Chinese educational contexts. EFL teachers should seek to strengthen their intercultural competence through training, further education abroad and self-study (Ding, 2013).

At Author 2’s university, EFL teacher education involves two semesters’ study of EFL pedagogy, including school practicum. Pre-service teachers are encouraged in the role of facilitator instead of being merely a knowledge imparter. In employment of language teacher educators, in Chinese universities, there is a trend to employ postdoctoral students and academics without teaching experience in primary and secondary education (Wang, Moloney and Li, 2013), thus recent field experience may be limited in many teacher educators. This project seeks to contribute particularly to change in China’s English curriculum reform, its impact on teachers and teacher education.

#### 4. Methodology

Narrative enquiry identifies experience as a story which becomes meaningful through interpretation. The narrative enquiry researcher tracks process, experience, and progress of the work through narrative writing. Building on recommendations (Barkhuizen, Benson and Chik, 2013) and the methodology of other studies (e.g., Clandinin and Connelly, 2000; Liu and Xu, 2013; Moloney & Wang, 2016; Tsui, 2007) this study designed its process into three methodological steps:

(1) Authors 2 and 3 acted as narrative writers. They independently wrote texts of first person reflective

narrative exploring their history and relationship with EFL and EALD teaching respectively. These texts are the data of the study.

(2) Authors 2 and 3 individually and alone, read the other’s narrative data carefully. This involved reading and making sense of the narrative data, coding for themes and recurring concepts, and writing up an interpretation of each other’s text. Author 1, a university academic involved in language teacher education, acted as critical friend, collaborator in analysis and research mentor.

(3) Using face-to-face and email communication, the three authors compared the thematic interpretations, engaged in dialogic negotiation, and developed a collaborative analysis. Through categorization and classification, perceptions in the data are linked to more theoretical concepts, and relationships can be identified between background influence, community membership and identity. Below, the narratives have been placed within a third person framework of analysis and commentary. We have endeavoured to view the narratives, not as factual accounts, but as constructions reflecting the investments and values of the narrators, as well as the narrator’s awareness of the collaborating readers’ perceptions.

### 5. Analysis of Data and Findings

#### 5.1 Interpretation of Author 2 Narrative Data

Author 2 begins her narrative by reflecting on her childhood experience of the significance of EFL education in China:

I had my primary education in Anhui Province in the 1980s. I was enrolled in one of the top junior high schools there when my family moved back to my hometown in Jiangsu Province. My parents were so confident that they would get me into one of the top high schools in Jiangsu with my previous scores, but I was rejected simply because I had learnt no English in my primary schools, while my counterparts in Jiangsu had already completed two years’ English learning. Two months later, by the time I was admitted to a nearby ordinary junior high school, they had already finished learning phonetic symbols. I was left behind.

This extract shows both the value attached to EFL study, and the early confidence and expectation of success, instilled in Author 2 by her parents, a recurring theme in her narrative.

Author 2 soon encountered Mr. Pan, the first of her important role models:

My English teacher Mr Pan was my class teacher,

strict and energetic at his late 20s. I owed my early learning success to Mr Pan. He set high standards for us and made a good effort to vary his teaching activities with singing, rhymes and games. He was lively and humorous. I reckoned him to be an early experimental practitioner of EFL pedagogy. We had many chances to present our dialogues to practise speaking although the classroom was still highly teacher-centred ... he was a role model as EFL teacher, he had his own way and methodology to achieve desired outcome in his teaching...we felt encouraged.

The qualities of Mr Pan which Author 2 most valued were his innovation, his expectations of his students, his independence in his pedagogy, and the motivation engendered in students.

In senior high school Author 2 began to appreciate the value of authentic texts and contextualised learning in the study of language. This informed her future education and teaching, as Author 2 implemented these methods in her own teaching. At university, Author 2 majored in English, but, noting the “boring theory-based linguistics courses”, she chose strategies such as listening to and reading authentic texts. When she began her teaching practicum she was “taken aback with no idea how to start teaching”, however her “passionate and caring” supervising teacher provided hands-on practical suggestions and advice on lesson planning and classroom management”.

As a beginning teacher Author 2 was provided with support and professional development activities. She notes the value of learning in seminars and workshops during which “new approaches and lively methods” were demonstrated and she was “inspired and eager” to try these methods in her classroom. However, constraints of education policies which focussed on summative examinations meant that Author 2 was unable to practise new teaching strategies in the classroom, resulting in frustration and a need for change.

Author 2’s master’s study in English Language and Literature at the East China Normal University (ECNU) was a contrast to her previous tertiary study. “I enjoyed my study in ECNU...my teachers were superb...I was struck by their passion and reflection in teaching”.

The pedagogy taught at the university closely aligned with Author 2’s own preferred teaching strategies and this enhanced her learning enjoyment, and sense of belonging to this EFL pedagogy community.

As her narrative progresses Author 2 demonstrates that she has become more confident as an EFL teacher

educator: “I came to realise what an important job I have been doing”. She is gradually acknowledging that she needs to shift “deeply rooted ingrained habits” in order to provide the best possible outcomes for her students. Those habits are a fundamental aspect of her growth and progression towards becoming an accomplished teacher educator. Even now, Author 2 views herself as not yet having achieved best practice in her chosen vocation: “Although I had been teaching EFL pedagogy in my university for 5 years, I still found myself less-equipped as an EFL teacher educator”.

Recently, Author 2 received a scholarship to further her studies in Australia as a visiting scholar. She comments that she is:

curious to learn about the latest trend in EALD education in Australia... and how that differs from the EFL education in China. I am learning from attending tutorials, exploring and thinking how all these activities and theories can better fit into my EFL context in China.

Such reflective comments show Author 2’s commitment to her students and her desire to ensure she is maximising their success by furthering her own learning.

In occupying both roles of EFL teacher and Teacher educator, Author 2 recognises that teaching and learning is a partnership where all stakeholders work together to acquire new skills:

my students learn from me as well as their peer learners....what happens in classroom is a dynamic two-way interaction.....peer learning is equally important resources [sic] in tutorials.

We observe tension in Author 2’s narrative between her admiration for aspects of teacher-centred traditional teaching methods (Halpin, 2014) and her desire to embrace new EFL pedagogy. Throughout her narrative, Author 2 highlights features of the traditional teacher in her admiration of some teachers: „well-organised and did everything neatly, she had good control of the teaching space and students....listened to her disciplined [sic] and attentively“; and yet, as a teacher educator, she views one of her own student’s attempts to scaffold and differentiate as daring and appealing to students with restless minds. The interpretation of Author 2’s narrative brought up some dialogic negotiation amongst authors. Author 3 observed what have been termed “traditional Chinese values” arising from a Confucian- influenced background, in Author 2’s narrative. Author 2 was surprised, and resisted the observation. She thought of herself as having moved away from such values and



positioned herself within a “Western” pedagogical approach to teaching and learning.

There is an underlying sense of frustration in Author 2’s narrative in that she recognises that current EFL teaching pedagogy, while breaking free from formal grammar and rote learning, remains constrained by an education system which is moving ahead at a slow rate of reform. It may also be suggested that communities of teachers like Author 2, however, have the capacity to bring about change. This tension has been noted also in China-educated teachers of Chinese as a foreign language, in studies of teachers adapting to the pedagogical expectations of global teaching contexts (Xu & Moloney, 2016).

Despite some lack of confidence in her English learning, Author 2 has consistently continued to pursue excellence in her work and shows passion to learn. This is evident in her on-going pursuit of higher order skills through academic progression and research. It may be suggested that the high aspirations and expectations held for and of her by those whom she respects, have underpinned her will to be successful, setting examples of excellence and influencing her choices.

Author 2 has attained a high level of professionalism and confidence in her ability. As her education progressed, she drew on her ability for English teaching and learning as well as being able to identify good pedagogy. She views herself as having a responsibility to educate her teachers in pedagogy which she understands/knows to be effective even though she herself has had little opportunity to practise these skills in the classroom.

Author 2 is a member of an EFL professional community in flux. She displays aspects of Wenger’s model of identity formation within this community. She shows engagement, deeply invested in improving her practice as a teacher educator, imagination (perceiving the broader significance of teacher education) and alignment (connection to others who are developing innovative pedagogy in EFL). She feels conflicted in her negotiation of meaning, within her broader China EFL context, as she struggles to achieve innovation in EFL, which, although growing in acceptance at the university teacher education level, may still occupy a marginalised place in school classroom practice.

### 5.2 Interpretation of Author 3 Narrative

Author 3 grew up in Sydney Australia. As a small child she was an avid reader. She recalls an anecdote from her mother: “when I was supposed to be asleep in my cot, as a 2-year-old, apparently I could be heard turning the pages of a magazine, looking at its content”.

This developed into a lifelong passion for reading and texts. Author 3 completed the Higher School Certificate (HSC) and later went to university part time to complete a Bachelor of Commerce. She worked as an accountant for 20 years as it “helped me to support my family better financially. But when my daughter grew up, I decided that I could do what I really wanted to do, which was teaching”.

Returning to university, she then completed a Bachelor of Arts with double majors in Linguistics and History followed by a Graduate Diploma of Teaching. She also completed a Master of Applied Linguistics.

I am good at language learning, and that passion for literacy followed me right into high school. In linguistics, I am keen on learning how to use English properly. Exactly. That is what I have to do.

I always read. I am an avid reader.

Author 3 is also a keen traveler. In her travel, she seeks out experiences of “discomfort”, for example trying to read newspapers in other countries, considering how to apply that experience in her teaching. Learning a new language is like stepping out of your “comfort zone” and by experiencing new cultures and languages (albeit for short periods of time) she is trying to seek commonality with her EALD students. Her own intercultural experience enables her to identify more with EALD students who are struggling with language communication as well as cultural acclimatization.

I love travel, cultures. I am brought down-to-earth when travelling. It is about knowing the people, the culture. I always buy a newspaper, and try to read or scan it for gist. These efforts remind me of the difficulty of speaking a second language. In speaking English overseas, I am conscious that I need to slow down, to use words that are easier for people to follow. Travel is a great reminder of what I need to do in the classroom. However uncomfortable the travel may be, it influences me, it gives me great understanding.

Author 3 trained in EALD methodology and completed her practicum teaching at a local Intensive English Centre (IEC), a turning point for her. She established a close working relationship with her mentor at the school, who was the Deputy Principal of the Centre. The Deputy Principal gave her opportunities to develop:

She recognized early on that I was passionate about teaching, when I did my practicum with the IEC. I did a lot more than was expected. As a mentor, she was tough. I strongly suggest one should grab hold of a mentor, as a young and new teacher because

mentors know how far to push you. I have learnt a lot from her.

When Author 3 finished her university training - five years ago from time of writing - she was offered a position as a teacher at the IEC. She has been there ever since, and has moved into leadership roles, including the coordination and support of incoming practicum teachers. At school she sees her primary role as ensuring newly arrived students from diverse backgrounds are supported in acquiring the English language, social and cultural skills they will need to access the high school curriculum and succeed in their new life in Australia. This is her vision in EALD teaching: "It's language competence. I want to give young learners opportunities to start a life in their new country".

The process of understanding the situation of EALD students and identifying with them is to make connections. As Fenner (2013, p. 62) noted „quite often, the empathy facet of ESL teachers' role can be just as powerful as their expertise in language acquisition and teaching technique". Author 3 reflects:

When it comes to the most important qualities as EALD teachers, I think it is definitely empathy, the knowledge to work with students who have settlement, social and emotional issues. They are isolated... Empathy is the key element to push students to learn. In that sense, you have to respect students; you have to give them all the support.

Author 3 was invited back to the university as an occasional guest speaker to the EALD methodology class and was eventually invited to become the teacher of the EALD methodology class, two hours per week. She has taught in this additional role for the past three years. Despite her short working hours, her accrued experience and participation in the university staff activities over three years positions her as a legitimate community member. She reflects on her enjoyment of both roles, her projection and investment of herself, and how each role enriches the other:

I enjoy being with young people, both teenagers and young adults. Young people are the present, unaffected. To be passionate, sharing your knowledge with them. That has been a dream all my life. It is also because I waited for so long, so I enjoy it even more. For both my university students, and transferring to my staff, I can give them knowledge. I keep my knowledge up to date. I am learning from my university students. It keeps me interested as well. When I talk to the university students, I can feel the passion, nurture the inspiration. If I inspire somebody to do something further, I have done my

job.

Author 3 sees a continuous learning cycle between herself, her school students, mentoring her staff at school, teaching and mentoring the pre-service teachers at university.

I have something to teach, to share. It was only five years ago that I sat there, in the university class. I know the difficulties. I can sympathise, I can give them the pedagogy they need. On the last student evaluation of my teaching at university, the students voiced their appreciation. They value the information I give them. I constantly update the unit guide to ensure relevancy and to reflect changing pedagogy.

We note here again a further instance of negotiated narrative analysis making traits visible. To her surprise, and in contrast to how she believes she teaches, it was pointed out to Author 3 her unconscious frequent use of "I" in her narrative, and her tendency to position herself as the source of knowledge, and the centre of the classroom.

We briefly note as a continuous theme in Author 3's narrative, her passion for high level literacy and linguistics knowledge, which is a feature of both her personal and professional identities. Together with her own passion for reading and linguistics study, Author 3 believes that high level of literacy, content knowledge and teaching pedagogies are essential for EALD pre-service teachers, in order to be able to impact EALD students' rapid language acquisition.

What they (pre-service teachers) are lacking is content knowledge. It becomes clear in assessment tasks when grammar and vocabulary, often are not used correctly. How can you teach English if you don't know it very well? Students who choose the unit must have completed some prerequisite linguistics units. Linguistics is the backbone of language. We should incorporate more grammar learning into the unit.

Author 3 sees all of these activities as part of her professional development and responsibility. She stresses the importance of further education and argues that an EALD teacher must be someone who loves challenges. Author 3 has enjoyed the challenge of career change, of travel and of postgraduate education.

We have observed Author 3's construct of her identity as EALD teacher and teacher educator. The narrative provides insight into the ecology of development occurring in language teachers interpreting their own teaching modelling, pedagogy, teaching beliefs and professional development. Notions

of teacher learning and its relation to teacher's professional development are recurring themes in her narrative. She believes that her movement between the role as EALD teacher and teacher educator is an active catalyst for learning and development. She places value on pre-service teacher needs in EALD teacher education and is also aware of new innovative methodologies which can be introduced and practised in the real classroom.

Author 3 values learning from community, from school colleagues and from her pre-service teacher students. She holds that the EALD teacher community in particular should stick together to assert their status as specialists, in view of their sometimes-marginalized position in the Australian school system: "Some schools will devalue the work of EALD teachers. They need encouragement and support from the top. They should get involved and change attitudes".

Author 3 is active in advocating, raising public and political awareness of the importance of EALD education. It is a challenging role which requires the community to stand together (Morgan, 1998).

## 6. Discussion and Concluding Remarks

This study investigated the narratives of two teachers who simultaneously occupy the roles of English language teacher and English language teacher educator. Despite differences in background and contexts, the study illustrates the shaping role of social context in the development of teacher educator knowledge, practice, and professional community membership. The study examines how the two teacher educators construct their dual roles and dual practice, model their identity as English language teachers, and negotiate their membership of two professional communities. The study demonstrates a dynamic ecology of learning occurring in the interchange between teacher and teacher educator roles and shows the learning potential of this situation in quality practice in teacher education.

There are a number of differences and commonalities in the narratives above. The narratives are firstly clearly grounded in very different social and educational backgrounds which have shaped particular beliefs and practice. The two narrators are diverse in age, life experience, and professional experience. The learning contexts of EFL and EALD are also very different, in rationale, student motivation and demands. For Author 2, English is a second language, whilst for Author 3 a first language. From her linguistic studies, Author 3 however has a critical perspective on the

language learning task for EALD students, and deliberately exposes herself to experiences of the learner position, when in a non-English speaking country. The curriculum they teach, both in their English language teaching, and their teacher education role, also differ. They differ also in their relationships to their professional communities. Author 3 exhibits a strong alignment and belonging with her EALD community, where her pedagogies are accepted and applauded, her leadership admired, her identity confirmed. Author 2 however has experienced some dissonance and ongoing negotiation with the EFL community to achieve widespread adoption of innovative pedagogies.

Nevertheless, we find a surprising number of commonalities also in the narratives. Both teachers share a passion for what they do, and a commitment to teaching and learning, both in themselves and their students. Both have created some degree of freedom for themselves in their teaching and their teacher education. Both are actively involved in seeking out continuous learning, through travel and further study, at considerable personal cost. They both see this continuous learning as integral to their personal and professional development, and to what they can offer to their students. In particular, they both have understanding of their own critical intercultural learning and the role this plays in English language learning. Freeman and Johnson (1998, p. 407) have argued for the need for teachers to be learners: "the knowledge base of language teacher education must account for how individuals learn to teach and for the complex factors, influences, and processes that contribute to that learning".

There is also in both narratives, a sense of agency and of creating their own independent space in leadership: Author 3 has agency in EALD leadership within her immediate school community, in mentoring and bringing her young teachers to new practice, insisting they keep up with new research developments. In Author 2, this is being achieved more in isolation, as a one-woman initiative, but with a strong sense of what she can contribute in the future to new development in her broader EFL community in China, especially through her work with pre-service teachers.

With their connections across communities, both teachers are able to open up possibilities for learning, and they have new perspectives that would not be apparent within one community alone. In their boundary encounters (Wenger, 1998), we can see that they construct new meanings and understandings of their

practice within the respective communities. The nature of their practice in the two teaching contexts also changes, as interactions and connections enable new ways of learning and new practices to emerge.

Most importantly, despite the differences in background, education, and beliefs, we find a common understanding of the learning ecology occurring in the circular dynamic between their roles of teacher and teacher educator. There is learning occurring for multiple stakeholders at multiple points in the relationships.

Author 3 uses her teacher educator role to both teach, and learn more from, pre-service EALD teachers, and thereby produces effective new members of the EALD teacher community. In this way she nourishes her own teaching and ensures a quality start for new teachers into the community: “I learn a lot from others and now I bring it back, it is a cycle. I also bring something to my staff meeting. It is like an eco-system; it develops in all ways”.

To mentor and to be mentored is a fluid multi-directional process, in that Author 3 is guiding preservice teachers and her staff and receiving guidance herself from her mentor on staff. The shift of roles nourishes her in her professional development and her concept of EALD teacher education. Similarly, Author 2 recognises that she has been mentored by various figures in her background. She revises her teacher education practice through learning from her pre-service teachers, and this also prompts continuous development of her own practice in EFL classes. And both teacher/ teacher educators contribute to an enclosing professional community of peer teachers, staff, community leaders, researchers. This is represented in Figure 1.

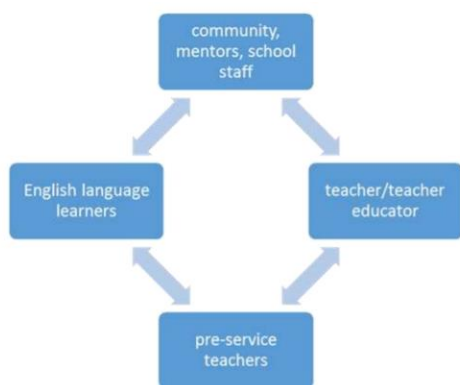


Figure 1. Multi-directional learning, for teacher / teacher educators.

This study’s use of a learning ecology metaphor,

seeks to express the interdependencies between learner and context(s) in producing developmental change. We have seen in the two narratives that cross-context links, and individual agency play an ongoing role in teacher/ teacher educator development. An ecology metaphor helps us to conceptualize teacher educator development as complex and interdependent. Such a metaphor is appropriate to capture the ever-unfolding learning interactions of teachers, students, and communities and the consequent fluidity of teacher educator identity.

While a case study, we believe the findings have relevance to a broad audience, in global attention to quality teacher education provision, and in particular to global EFL practice. The study raises questions in teacher education practice, in light of the increasing trend in universities to employ research academics who may become in time increasingly distanced from the school context, in teacher education roles. While the focus of this study was on the teacher educators, it is clear that preservice teachers’ skills, knowledge and professional identity may benefit from the dynamic ecology created by their instructor moving between school teacher and teacher educator roles. The study suggests there is a strong rationale for the employment of greater numbers of practising teachers in teacher educator roles.

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# The Existing Problems and Innovative Research of Eco-Management in Sichuan Minority Regions

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**Abstract:** The important thought of Xi Jinping's ecological civilization construction is a hot topic in the academic circles at present in China. Since the eighteenth Party Congress, general secretary Xi has published a series of important speeches, which formed an important thought of ecological civilization construction. These ideas are constantly supplemented and improved in practice, and gradually form an important theory of ecological civilization construction in China. This paper argues that it is of great value and significance to study the innovation of ecosystem management in ethnic areas for the construction of ecological civilization, the theory of ecosystem management, and the practice and development of China's ecological civilization construction in the new era.

**Keywords:** Minority areas, ecosystem management, innovation, Sichuan, China

## 1. Introduction

Ecological prosperity and decline lead to civilization prosperity and decline. China has earlier raised the concept of ecological civilization and ecological civilization construction as national development strategies, selected an ecological civilization form, adopted a series of scientific and effective measures to protect the ecological environment, and gradually explored a road of ecological civilization construction with Chinese characteristics. However, with the increasingly prominent contradiction between development and resources and the environment, ecological problems have become more severe and prominent. As a new and profound management paradigm revolution in the history of management, ecosystem management has emerged in response to the needs of the times, which urgently requires the government to upgrade the effective management of ecology to an important responsibility behavior of the public and the government. In all aspects of the actual management of enterprises, it has begun to show an obvious trend of ecologically sustainable development. The most critical problem in the research of ecological civilization construction is the innovation of ecosystem management, which is how to promote the construction of ecosystem civilization in China by strengthening the innovation of ecosystem management and coordinate

the role of government, enterprises, and non-governmental organizations.

## 2. Overview of Ecosystem Management in Sichuan Minority Areas

### 2.1 The connotation of ecosystem management

Ecosystem management or eco-management originated in the United States in the 1970s, has become hot research and urgent problem to be solved in practice. Ecosystem management has a very broad theoretical basis across the disciplines of biology, economics, ecology, management, environmental science, and system theory. Due to the complexity of Ecosystem management itself, the current theoretical and practical research is still in development. Different institutions and scholars define Ecosystem management from different perspectives and reveal the connotation and nature of ecological management. Although there are still immature aspects, there are some common understandings. We can define ecological management as we should use modern science and technology, ecology, economics, management, and other interdisciplinary principles to manage human actions, try to balance the conflict between development and ecological environment protection, reduce various destructive effects on the ecological environment, and finally realize the coordinated and sustainable development of economy, politics, culture, society, and

ecological environment.

## **2.2 The current situation of eco-management in Sichuan minority areas**

Sichuan Province is a multi-ethnic western province, with the largest Yi inhabited area, the second-largest Tibetan inhabited area, and the only Qiang inhabited area. There are 51 Minority Counties, including Ganzi, Aba, and Liangshan Autonomous Prefectures, and Mabian, Ebian, and Beichuan autonomous counties. Sichuan Minority Counties cover an area of 302100 square kilometers, accounting for 62.14% of the province's total area. Since the implementation of the western development strategy, the Sichuan provincial Party committee and government have proposed to build Sichuan into a strong economic province in the western region and an ecological barrier in the upper reaches of the Yangtze River. The ecological environment in ethnic minority areas will be greatly improved soon through the comprehensive treatment project of the ecological environment. After years of hard work, the construction of ecological civilization in Sichuan minority areas has made a breakthrough, mainly in the following aspects: first, ecological protection has been continuously strengthened, the planning of main functional areas has been fully implemented, and the ecological barrier in the upper reaches of the Yangtze River has been further strengthened. Through the promotion of large-scale greening of the whole Sichuan Province, the forest and grassland coverage rate has increased significantly. Second, the quality of the ecological environment has improved significantly, the total emission of major pollutants has decreased significantly, the average annual concentrations of PM10 and PM2.5 have both declined, the green and low-carbon circular development model has taken shape, and there are more and more high-quality ecological products in the market. Third, implement the negative list of industrial access in key ecological function zones, and further strengthen environmental protection supervision. But at the same time, we should also see that there is a long way to go for the coordinated development of ecological civilization construction and national economy. The present situation of the low level of ecological civilization construction in Sichuan minority areas. Water resources, forest resources, grassland resources, wild animals and plants, and other resources have been damaged to varying degrees, and the ecological problems caused by pollution are still very serious.

## **3. The Main Problems of Ecosystem**

### **Management in Sichuan Minority Areas**

#### **3.1 The consciousness of ecological crisis management is not strong, and the system is not perfect**

The importance of strengthening ecological construction and management in Sichuan minority areas is fully recognized and highly valued, but there is still a vague awareness of ecological crisis management, and the management system is not perfect. The main performance is as follows: first, the government in ethnic minority areas does not grasp the policy of ecological construction and management in the new era. Regional governments have long been accustomed to the development path thinking mode of central financial support and local resource development, so they lack the awareness of ecological environment risk and the concept of ecological crisis in the new era, and the initiative and prevention of ecological crisis are not high. Second, the construction of an ecological crisis management mechanism is not perfect, and the ability of optimizing the combination of emergency resources is seriously insufficient. The investigation shows that the construction of the ecological crisis management mechanism of the government in ethnic minority areas is not perfect. When the ecological crisis breaks out in ethnic minority areas, due to the influence of geographical environment, historical background, religious culture, leadership, management, and other reasons, it is unable to mobilize all kinds of resources actively and effectively. Third, the construction of the ecological crisis management information system platform of the government in ethnic minority areas is relatively backward, and even some places have not established the ecological crisis management information platform so far, which leads to information asymmetry and miss many of the best opportunities for early warning and prevention.

#### **3.2 The enterprises in minority areas are not active in implementing ecosystem management mode**

The starting point of enterprise ecosystem management is the harmonious relationship between human and nature, which is a systematic and dynamic way to think and deal with problems. This mode is fully promoted and implemented in all kinds of enterprises at all levels. It is necessary to implement the ecological concept in all aspects of enterprise management by following the ecological law to manage enterprises scientifically and effectively. Enterprises should reasonably plan the career of employees, so as to promote the common progress and development of



employees, enterprises, and nature. However, it is rare for enterprises in ethnic areas to consciously implement ecosystem management, and their enthusiasm is generally not high. The production technology in ethnic minority areas is relatively low, and most of them are primary products. The cost of primary products is generally low, so enterprises do not need to invest a large cost. However, the raw materials in ethnic areas are generally rich, and all enterprises can obtain corresponding profits by producing primary products, so they will not consider adopting ecological mode. ecosystem management mode means developing new technology and purchasing new equipment, which will increase the cost of enterprises. Therefore, the enthusiasm of enterprises in ethnic areas to implement ecosystem management mode is not high.

### **3.3 The government in ethnic minority areas lacks standard and effective supervision and incentive mechanism on whether enterprises implement ecological management mode**

Due to the unclear division of power and responsibility in the process of management, the governments in some regions even integrate the three functions of supervision, management, and execution, which is not conducive to effective supervision. Even if the enterprise does not adopt the ecosystem management mode, it cannot take severe punishment when it causes waste or damage to resources. The cost of ecological damage is low, and it will not consider the protection of the ecological environment in the pursuit of high profits. At present, there is no effective system to establish a public reward and punishment mechanism. For citizens who save resources, we should increase the intensity of rewards, actively play up the atmosphere of protection and conservation in society and take advantage of the particularity of ethnic areas. For example, in Liangshan Yi District, if an individual or organization has advanced deeds or illegal acts of protecting the environment and saving resources, it can give corresponding rewards or punishment to the Yi family and individual, which will encourage other members to follow their positive behavior and will not do illegal environmental protection behavior.

### **3.4 The public in minority areas lack the common sense of ecological environment protection and education of ecological crisis**

At present, the government lacks the common sense of ecological environment protection and ecological crisis education for the public, and the knowledge education and training on ecological civilization are insufficient. Due to the lack of

knowledge of ecological environment protection and awareness of ecological responsibility, the public will unconsciously consider the damage to the ecological environment and the ecological compensation to meet the needs of a certain aspect in real life due to their own survival and economic interests. Once this kind of illegal behavior of damaging the environment appears in practice, the public will often blame the government for not having publicity and education or not understanding the relevant provisions of environmental protection, which will lead to casualties and property losses. There are many contradictions and conflicts in the treatment, which is not conducive to the public's active participation in environmental protection.

## **4. Multi-dimension Research on Ecosystem Management Innovation in Minority Areas of Sichuan Province**

This paper takes the current ecological civilization construction as the background and studies the innovation of ecosystem management from the concept, mechanism, and policy.

### **4.1 Innovation of ecosystem management concept**

The ecosystem management system is composed of different subsystems such as human, organizations, and the environment. As an integral part of the ecosystem, human beings have been developing their functions by learning the knowledge of ecological theory and deepening their cognition. The innovation of ecosystem management concept is the logical starting point and foundation of ecosystem management innovation. The construction of ecological civilization in China must be guided by the complex scientific theory, and the governments at all levels should supervise and manage it to prevent enterprises, individuals, or other social organizations from damaging the ecological environment and promote the sustainable development of economy and society. At the same time, starting from the establishment of ecological values and green consumption, we should integrate the rational thinking of ecological culture into scientific and technological innovation, strengthen the integration of ecological culture and science and technology, develop ecological products, and realize ecological value.

### **4.2 Innovation of ecosystem management mechanism**

Mechanism refers to the structure and function of its system organization and operation, as well as the way and process of interaction among various elements. According to the current development level and

situation of ecosystem management mechanisms in China, we need to build a collaborative management mechanism under the guidance of the government. In the whole complex system of ecological management, to complete ecological management, we must adhere to the leadership of the government, actively participate in various parties, and play the important role of all parties. Under the market principle, this mechanism relies on the common recognition of the public rather than the compulsory authority of the government. It has changed from the past single, bottom-up to two-way and multiple, expanded the scope of decision-making, implementation, supervision, and other subjects in ecosystem management, and enhanced the efficiency of decision-making and the enthusiasm of all kinds of subjects to participate. At the same time, the collaborative governance of ecological management enables multiple management subjects to get relevant ecological information in time, to ensure that the development strategy of enterprises is consistent with the goal of ecological development, make scientific decisions in time, and improve the efficiency of ecological management. In addition, the government can also raise funds through this cooperation mechanism and reduce the government's financial expenditure on ecosystem management.

#### **4.3 Ecosystem management policy and legal innovation**

In the practice of ecosystem management, it is necessary to use policies and laws to support and protect. In the sixth collective study of the eighteen Central Political Bureau, general secretary Xi Jinping pointed out that "the most stringent system is the strictest rule of law to protect the ecological environment". If we want to get out of the predicament of ecological deterioration, we must improve our ecological public policy and ecological environment legal system. We should innovate ecological public policies, attach importance to environmental protection policy directives, deepen the reform of fiscal, taxation, and financial system, and further establish the concept of ecological talents. To innovate the ecological legal system, the government

should create and maintain the legal system environment of the green economy, constantly update, and improve the laws and regulations related to ecosystem management and adjust measures to local conditions. According to the economic development status and specific environmental problems in ethnic areas, a series of special local laws and regulations with strong pertinence and high applicability should be formulated to further clarify the environmental function zoning, environmental protection, and environmental protection. The legal status of eco-city and eco-park should be enhanced, the public's awareness of environmental protection should be enhanced, and the supervision of illegal acts that damage the ecological environment should be strengthened. Once investigated and dealt with, the economic punishment, administrative and criminal responsibilities should be directly investigated, to improve the scientific and effective work of China's environmental supervision department and provide important data and implementation basis for environmental monitoring practice.

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# Researching the Relationship between Years of Schooling and Cultural Consumption

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**Abstract:** Cultural consumption characterizes its cultural value, so it relies on the cultural capital of consumers to identify the cultural value of the items of cultural consumption. The years of schooling are the institutional embodiment of cultural capital, and therefore the years of schooling are highly related to cultural consumption. The theme of the research reported in this paper is how the years of schooling work independently on the cultural consumption, compared with other impact elements such as the economic income, the indigenous culture and the difference between the city and the country, and whether the differential of cultural consumption can cover the structural social difference caused by social stratification. The research took the scarcity of cultural consumption items as the standard of the classification and used the multinomial logistic regression and the data from CGSS2013 to analyze the relationship between the years of schooling and cultural consumption. The research finds that the years of schooling influence the cultural consumption in a wide range, and whether cultural consumption is scarce, the more years of schooling those who hold, the more often they do cultural consumption to form the monopoly privilege.

**Keywords:** Years of schooling cultural consumption social stratification, multinomial logistic regression, CGSS2013

## 1. Introduction

Social stratification implies the type of life to which members of society have access, and that requires specific conditions including not only economic capital but also cultural and political capital. In contrast to economic and political capital, the stratification structure of cultural one is particularly unique in that it reaches into the differences in the cognitive system of individuals rather than external things such as money or power, and thus the proposition of how cultural capital shapes individual behavior patterns has its unique value.

The discussion about class society has been extended from Marx's economic production to cultural consumption, like the cultural industry theory of Horkheimer and Adorno, Bourdieu's literary field theory, and Baudrillard's consumer society theory, all of which introduce the perspective of class into cultural consumption.

Continuing the research on the relevance of social stratification structures within the cultural field, this study focuses on the relationship between cultural capital and cultural consumption to investigate how the amount of cultural capital affects cultural consumption.

Compared to other consumption, cultural consumption emphasizes its cultural values and contexts requiring relative cultural capital, and thus the amount of cultural capital influences the access to cultural consumption resources.

Consequently, this quantitative study will focus on exploring how the difference in cultural capital, i.e., the difference in years of education, affects the choices and patterns of cultural consumption items with CGSS2013 data and multi-category logistic regression models.

## 2. Literature Review and Theoretical Construction

### 2.1 Social stratification and cultural consumption

Compared with commodity consumption, cultural consumption emphasizes its cultural values. Compared with cultural activities, cultural consumption emphasizes its economic attributes. So, the definition of cultural consumption is a kind of consumer behavior that emphasizes cultural value. Consumers of cultural consumption can be classified according to specific social stratification criteria.

Certain field surveys within specific regions do not

systematically classify the respondents. For example, Wang Ming's (2006) study in Town A was based on the current recreational status and characteristics of the overall community population. Although the distinction of elderly, youth, and adolescents was made in discussing the hierarchy of residents' recreation, Wang Ming considered the community population of A town as a whole and did not distinguish the substantial cultural consumption differences among different groups. Also, in their study on the tendency of leisure mode selection and satisfaction evaluation among residents of small and medium-sized cities, Jiang Li and Lou Jiajun (2002) only made an analysis of the collective cultural consumption characteristics of the residents of Xinxiang City without population classification. Such studies for a geographic unit without introducing a social stratification model, we can only see the cultural consumption characteristics of a certain area but cannot understand exactly who within the area promotes or inhibits these characteristics.

In contrast, Tally Katz-Gerro (1999) consciously relates to social stratification structures when studying "leisure activities" and "musical preferences". Gerro's approach to social stratification "follows a social analysis perspective that alongside economic class grants significance to other topographical elements of society and accepts the existence of multidimensional bases of stratification" (Tally Katz-Gerro, 1999). Based on the above view of social stratification, he argues that "a variety of cultural clusters constitute a source of fragmentation between and within classes, races, genders, and other groups, which enables the exercise of closure" (Tally Katz Gerro, 1999).

## 2.2 Other variables on cultural consumption

Among demographic variables, geographical and urban-rural differences are the criteria used by many scholars. Tian Hong and Wang Hanying (2016) found that "urban residents in the eastern, central, and western regions all have significantly higher cultural consumption expenditures than rural residents, with the largest urban-rural differences in the western region, followed by the central region, and the smallest urban-rural differences in the eastern region." Li Rui (2013) also concluded that "there is a large gap between urban and rural per capita cultural consumption", and the gap is widening year by year. Li Rui's study of regional differences is also very similar to Tian Hong and Wang Hanying's findings, and she found that "the per capita cultural consumption in the eastern region is significantly higher than that in other regions" and that "the gap in per capita cultural consumption is smaller in

the central, western and northeastern regions" (Li, 2013). Based on the demand hierarchy and income elasticity, Mao and Sun (2016) concluded that after 2003, "cultural consumption gradually becomes a 'non-urgent' consumption demand of rural residents" and "cultural consumption accounts for urban residents," and "the share of cultural consumption in the income and consumption expenditure of urban residents will first increase and then remain relatively stable". Such studies directly compare the differences in cultural consumption items between urban and rural and between eastern, central, and western populations. However, there is social stratification within every region, and it is difficult to answer such questions whether high cultural consumption expenditures in urban/eastern areas are shared by all residents or monopolized by some class, and whether rural/central/western residents are collectively weak in cultural consumption. In addition to the differences in the geographical distribution, There is a need for researchers to do class stratification within each social unit to further analyze the distribution of cultural consumption.

In other studies concerning multiple variables, some researchers have considered only physiological variables, such as age and gender. Zhang Hao's (2014) study in J town, L county, East Henan examined the uniformity and differences in cultural consumption between rural elderly males, rural elderly females, and between male and female genders of middle-aged and youth groups.

Some empirical studies that included sociological variables did not mention years of education. The independent variables used in Xue Pin's (2010) study on lifestyle were gender, age, occupation, income, and geography. In the study of urban residents' leisure satisfaction by Lingfei Wu (2013), the independent variables included gender, age, and occupation. The above studies did not consider the possible influence of cultural capital variables.

While other variables are important, cultural consumption differs from that of staple commodities or luxury goods because it includes the cultural meaning value. In addition to the same characteristics as other consumptions, and the cultural capital variable needs special attention.

## 2.3 Existing studies on the impact of cultural capital on cultural consumption

Compared to the previous studies, the empirical studies that include cultural capital variables can well illustrate the impact of cultural capital on cultural

consumption, but they still have flaws.

The first problem is that the consumption items are not categorized. For example, in the study of cultural consumption of classical music, Jörg Rössel (2011) emphasized the impact of cultural capital on the consumption of classical music. He also set up specialized cultural capital variables, such as "reading of special-interest opera magazine," "learning how to play an instrument" and "visiting a music school" (Rössel, 2001). Although the measurement of cultural capital is very detailed, it is difficult to generalize the findings to other cultural consumption items. Another example is Chen Zhengwei's (2002) study of the leisure patterns of Chongqing residents. This study covered literacy, nature of employment, economic income, and age. Chen only lists a few specific items (watching TV, reading newspapers, listening to music at home, playing outdoor games, and playing mahjong) but did not define the differences (elegant/vulgar or common/rare) behind them, resulting in Chen's study only describing the preferences of different groups of people for specific cultural consumption items.

Another problem is the lack of sufficient attention to and deep research on cultural capital. Some studies have identified the impact of cultural capital but have not explored it in depth. For example, Xiang Ming's (2015) study on cultural consumption of rural residents incorporated influencing factors such as the real per capita income, the demographic structure, the level of education, regional infrastructure, the level of construction of regional cultural facilities, and geographical location. Regarding the influence of cultural capital, Xiang Ming (2015) concluded that "the education level of rural residents, expressed by the illiteracy rate in rural areas, has a significant negative influence on the cultural consumption share of rural residents, i.e., a higher regional illiteracy rate leads to a lower cultural consumption of rural residents." However, in the conclusion part, Xiang Ming only considered the role of income, household equipment consumption and rural cultural facilities construction, but did not pay attention to the important role of cultural capital. The lack of further discussion about cultural capital made it difficult to explore the intrinsic character of cultural consumption.

### 3. Research Hypotheses

First, I shall examine how the years of education affect cultural consumption patterns. After that the scarcity of cultural consumption items will be compared.

This study proposes two hypotheses: 1. Years of education play the largest role among multiple influencing factors affecting cultural consumption; 2. People with high years of education prefer scarcer cultural consumption items.

#### 3.1 The effect of years of education on cultural consumption

Chen Jin (2015) argued that cultural capital influences the choice of cultural consumption more than economic capital, but he did not compare other demographic variables. Years of education will represent cultural capital, and the different influences of respective variables will be examined. At the same time, years of education change individual dispositions, preferences, and inclinations, about which Bourdieu (1984, p.476) also said: "The contradictions or paradoxes to which ordinary language classifications...which ought really to be called scholastic, since they all presuppose school, i.e., leisure, distance from urgency and necessity, the absence of vital stakes, and the scholastic institution which in most social universes is the only institution capable of providing all these" The influence of years of education on individual dispositions produces a categorization of social life, which includes the stylized treatment of cultural consumption.

The choice of cultural consumption items is influenced by some mind model given to certain class members sharing similar educational backgrounds, encouraging them to choose a specific cultural consumption pattern and to regard it as the best one.

However, this stylization of cultural consumption can be constrained by economic capital and geographic elements. The goal of hypothesis 1 is to compare dispositional tendencies shaped by years of education to external constraints of consumption ability and choice range.

#### 3.2 Scarcity of cultural consumption items

People with high years of education need to show their cultural capital utilizing having a monopoly on a particular cultural consumption pattern. There are two ways of monopoly: high-cost and ascetic consumptions.

High-cost consumption is correlated with income variables that deter low-income people by raising the cost of a particular cultural consumption pattern. High-income occupations are affiliated in the job market with industries such as management, high-tech, and finance that require college schooling and high years of education. People with high years of education can use their economic capital to express cultural capital advantage.

On the other hand, ascetic consumption is something that people with low education do not have the training to enjoy. Almost all consumption of art appreciation is ascetic consumption, where people who are not familiar with artworks and ignorant of art history cannot have fun, whereas people with high education levels use their monopoly of art knowledge to enjoy the pleasure of ascetic consumption.

These two types of consumption belong to different social classes. The ascetic consumption belongs to a class with high years of education but whose income does not fully match their expectation, and the members of these classes "performed with a frequency and regularity which take away any 'extraordinary quality, are in a sense governed by the pursuit of maximum 'cultural profit' for minimum economic cost'." (Bourdieu, 1984, p.270) Conversely, high-cost consumption is typical of conspicuous consumption, and the higher the cost, the higher the value of such consumption. This pattern, which most people cannot afford, belongs to the ruling class with high economic capital, which is heavily overlapped by holders of high years of education.

But this classification does not simply distinguish the role of economic and cultural capital. Other factors such as ethnics and geography are also involved in, so it requires further research examining the relationship between cultural capital itself and the scarcity of cultural consumption items.

#### 4. Research Data and Research Methodology

##### 4.1 Statistics of the variables

The cultural consumption items in this study were derived from the CGSS2013 (The data source for this study was Chinese General Social Survey CGSS 2013, with the dependent variable from A30 and the independent variables from S41 A2 A3 A4 A5 A7a A8a A10 A18.) lifestyle section "In the past year, did you often do the following activities in your free time" (A30), where the options for this question included 1. Watching TV or DVDs 2. Going out to cinemas 3. Shopping 4. Reading books/newspapers/magazines 5. Cultural activities (listening to concerts, watching shows and exhibitions) 6. Gathering with relatives who do not live together 7. Gathering with friends 8. Listening to music at home 9. Participating in sports 10. Watching sports matches live 11. Doing handicrafts (such as embroidery, woodworking). According to the cultural value, I chose "watching TV or DVDs", "going out to cinemas", "reading books/newspapers/magazines", "participating in cultural activities", and "

Listening to music at home ". "The two sets of hypotheses will handle the above options differently, and the classification results will depend on the hypotheses (See Appendix 1: Table 1).

Each of the above cultural consumption items was assigned the values of "every day", "several times a week", "several times a month", "several times a year" "However, I did not choose ordinal level variable of regression analysis because the frequency assignments above are not equal. However, I did not choose the logistic regression model with fixed-order variables because the distance between the above frequency assignments was not equal, and it did not meet the requirements of the ordinal level variable of regression analysis. Eventually, this study used the polychotomous logistic regression model.

The independent variable was years of education, and the education level variable in CGSS 2013 was treated as the years of education.

The control variables are composed of demographic variables, including gender, age, geography, ethnicity, religion, annual income, political affiliation, and household registration, where the value of annual income will be turned to the logarithm (See Appendix 2: Table 2).

##### 4.2 Re-operationalization of the dependent variable

The first hypothesis requires examining the effect of years of education. Within regression modes of the five cultural consumption items, I shall compare years of education with other independent variables on the times of their significance in regression modes.

The second hypothesis demands to pair the dependent variables: "watching TV or watching DVDs" versus "reading books/newspapers/magazines" and "going out to the movies" versus "attending cultural events". "The latter of each pair is considered much scarcer.

#### 5. Data Analysis

##### 5.1 Regression analysis results

In the regression model of "watching TV or DVD" (See Appendix 3: Table 3), people who watched TV or DVD in "weeks" and "months" were found enjoying but not having time. 22.38% more people in the eastern region than in the western region watched TV or DVDs several times a month. More people in the central region than in the west watched TV or DVDs several times a week, a month, and a year. Men were more likely than women to watch TV or DVD several times a week, a month, and never. The lower the age, the more people

watched TV or DVD several times a week, a month, and a year. The lower the annual income, the more people watched TV or DVD several times a month, a year, and never. Party members were 24.72% less likely than non-party members to watch TV or DVDs several times a month. Above 50% more Han Chinese than minorities watched TV or DVD several times a week and a month. Religious people were 28.54% less likely than non-religious ones to watch TV or DVDs several times a month. In rural areas, 11.85% more people than in urban areas watched TV or DVDs several times a week.

The more years of education, the fewer people watched TV or DVD several times a week, a month, and never. In other words, the higher the years of education, the more people had a habit and enough time to watch TV or DVD every day.

In the regression model of "going out to cinemas" (See Appendix 4: Table 4), more people in the eastern region went out to cinemas several times a week, a month, and a year than in the western region. More people in the central region than in the western region went out to cinemas several times a week, a month, and a year. The lower the age, the more people went out to cinemas every day, several times a week, a month, and a year. The higher the annual income, the more people went out to cinemas several times a month and a year. Party members were 30.47% more likely than non-communists to go out to cinemas several times a year. Han Chinese was 29.82% more likely to go to cinemas than ethnic minorities. Religious people were 57.85% less likely than non-religious ones to go out to cinemas several times a week. Fewer people in rural areas than in urban areas went out to cinemas several times a week, a month, and a year.

The more years of education, the more people went out to cinemas several times a week, a month, and a year. Since most people do not go out to the movies every day in general, week, month and year are the common frequency units of going out to cinemas, and so people with high education years enjoyed going out to cinemas.

In the regression model of "reading books/newspapers/magazines" (See Appendix 5: Table 5), more people in the east than in the west read books, newspapers, and magazines every day, several times a week, a month, and a year. Fewer people in the central region than in the west read books, newspapers, and magazines several times a week, a month, but 19.96% more did several times a year. Men were more likely than women to read books, newspapers, and magazines every day, several times a week, a month, and a year. The higher the age, the more people read books,

newspapers, and magazines every day, whereas the lower the age, the more did so several times a week, a month, and a year. The higher the annual income, the more they read books, newspapers, and magazines daily, several times a week, a month, and a year. Party members were more likely than non-party ones to read books, newspapers, and magazines every day, several times a week, a month, and a year. Han Chinese was less likely than ethnic minorities to read books, newspapers, and magazines every day and several times a month. Religious people were 26.66% less likely than non-religious people to read books, newspapers, and magazines several times a week. More than 50% less the rural population than the urban population read books, newspapers, and magazines every day, several times a month, and a year.

The higher the number of years of education, the more the population read books, newspapers, and magazines daily, several times a week, a month, and a year.

In the regression model of "participation in cultural activities" (See Appendix 6: Table 6), cultural activities in "days" usually are simple, whereas cultural activities in other time units are more complex or elegant. In the eastern region, 46.95% fewer people than in the western region participated in cultural activities every day and 42.33% more often several times a month. Fewer people in the central region than in the western region participated in cultural activities every day, several times a week, and a month. 38.80% fewer men than women participated in cultural activities every day. The lower the age, the more people attended cultural activities several times a week, a month, and a year. The lower the annual income, the more they attended cultural activities every day, whereas the higher the annual income, the more they did so several times a month and a year. Party members participated in cultural activities more often every day and several times a year than non-party people. Han Chinese was 167.78% more likely than ethnic minorities to participate in cultural activities several times a week. Religious people are less likely than non-religious people to participate in cultural activities several times a week and a month. Rural people are less likely than urban people to participate in cultural activities every day, several times a week, a month, and a year.

The more years of education, the more likely people were to attend cultural events several times a week, a month, and a year. Like the "going out to cinemas" item, complex or elegant cultural activities are measured in weeks, months, and years for most people,

and so people with high levels of education participated in complex or elegant cultural activities at all frequencies.

In the regression model of "listening to music at home" (See Appendix 7: Table 7), fewer people in the east listened to music at home every day and several times a month than in the west. Fewer people in the central region listened to music at home every day, several times a week, a month, and a year than people in the west region, implying that the most people in the west region listened to music at home. Fewer men than women listened to music at home every day, several times a week, a month, and a year. The lower the age, the more people listened to music at home every day, several times a week, a month, and a year. The higher the annual income, the more they listened to music at home several times a week, a month, and a year. Party members were more likely than non-party people to listen to music at home every day, several times a week, a month, and a year. More than 50% fewer Han Chinese than ethnic minorities listened to music at home every day, several times a week and a year. Religious people were 34.56% less likely than non-religious people to listen to music at home several times a week. Fewer people in rural areas than urban areas listened to music at home every day, several times a week, a month, and a year.

The more years of education, the more people listened to music at home every day, several times a week, a month, and a year, given that listening to music at home is much more convenient than going to a concert hall, which was included in the previous project, and that the time can be controlled at will.

## 5.2 Hypothesis testing

### (1). Constant effect of years of education variable

In the above five regression models, the higher the years of education, the more cultural consumption was done at each corresponding consumption frequency, indicating that years of education have an important and stable influence on cultural consumption, while other important influencing variables such as annual income, region, and household registration have unstable effects. In other words, compared to the region, income and household registration, years of education affect a wide range of cultural consumption items significantly at each consumption frequency, so the first hypothesis that "years of education play the largest role among multiple influencing factors affecting cultural consumption" is valid.

### (2). The relationship between years of education

### and scarcity of cultural consumption items

Within the cultural consumption items with different scarcity, "watching TV or watching DVDs" versus "reading books/newspapers/magazines" or "going out to the movies", there was no clear preference among well-educated people. Hypothesis 2: "people with high years of education prefer scarcer cultural consumption items." is not valid.

## 6. Summary and Conclusion

Cultural consumption consists of many items, each of which is influenced by different factors, but the influences of years of education are consistent in the way that the higher the years of education, the more often the corresponding population adopt this cultural consumption item, which implicates that as cultural capital holdings grow, the corresponding population gradually monopolize cultural consumption. Regardless of the scarcity of cultural consumption items, those with rich cultural capital tend to engage in all patterns of cultural consumption more often than those with relatively poor cultural capital. The overturning of the second hypothesis shows the monopoly of the Chinese cultural elite on overall cultural consumption. There are no popular cultural consumption items left to be controlled by the low-educated population. The conclusion does not mean that the low-educated population does not engage in cultural consumption, but rather that the activists of the entire cultural consumption are cultural elites and that the entire cultural industry sets a uniform educational threshold rejecting a considerable portion of the masses with low cultural capital.

As a result, the current policies on cultural consumption should focus on how to introduce the masses with low cultural capital into the cultural consumption market, instead of how to improve the taste of mass cultural consumption. In addition to building cultural consumption facilities, the government needs to promote cultural consumption patterns suitable for the masses.

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**Appendix1: Table 1. Dependent variables from Chinese General Social Survey (CGSS2013)**

<b>Dependent variable</b>	Daily	Several times a week	Several times a month	Several times a year	Never
Watching TV or DVDs	7,463 65.36%	2,530 22.16%	821 7.19%	311 2.72%	294 2.57%
Going out to cinemas	41 0.36%	160 1.40%	726 6.37%	2,543 22.30%	7,935 69.57%
Reading books /newspapers /magazines	1,219 10.70%	1,604 14.08%	1,978 17.36%	2,176 19.10%	4,414 38.75%
Participate in cultural activities	102 0.89%	251 2.20%	686 6.01%	2,369 20.75%	8,008 70.15%
Listen to music at home	1,204 10.57%	1,938 17.01%	1,747 15.34%	1,916 16.82%	4,586 40.29%

The first row of data is the frequency, and the second row of data is the percentage

**Appendix 2: Table 2. The dependent and control variables from 2013  
Chinese General Social Survey (CGSS2013)**

<b>Categorical variables</b>	Take value	Frequency	Percentage
Gender	Male	5,756	50.32
	Women	5,682	49.68
Region	Western Region	2,361	20.64
	Eastern Region	4,564	39.90
	Central Region	4,513	39.46
Ethnicity	Ethnic Minorities	968	8.47
	Han Chinese	10,458	91.53
Religious beliefs	Non-religious	1,272	11.13
	Belief in religion	10,159	88.87
Political Appearance	Non-Communist	10,211	89.79
	Members of Communist Party	1,161	10.21
Household Registration	Urban Account	5,083	44.53
	Rural household registration	6,333	55.47
<b>Continuous Variables</b>	Scope	Average value	Standard deviation
Age	[17, 97].	48.60	16.39
Years of Education	[0, 19].	8.72	4.64
Annual income	[ 1, 1000000]	23814.54	36753.19
Logarithm of annual income	[0, 13.82].	8.52	3.26

Annual income of 0 data to 1, household statistics do not include military stat

**Appendix3: Table 3. Analysis of consumption frequency of "watching TV or DVD"**

Independent variable	Several times a week	Several times a month	Several times a year	Never
Eastern Region (using the western region as reference)	0.0328 (0.0703)	0.202* (0.119)	0.0783 (0.192)	-0.0748 (0.184)
Central Region (using the western region as reference)	0.132* (0.0674)	0.231** (0.116)	0.351* (0.182)	0.162 (0.164)
Male (using women as reference)	0.173*** (0.0525)	0.293*** (0.0866)	0.0759 (0.136)	0.592*** (0.140)
Age	-0.0230*** (0.00197)	-0.0337*** (0.00331)	-0.0170*** (0.00506)	0.00151 (0.00494)
Years of Education	-0.0296*** (0.00784)	-0.0281** (0.0132)	0.0223 (0.0208)	-0.108*** (0.0190)
Annual income (ln)	-0.0119 (0.00806)	-0.0222* (0.0127)	-0.0473** (0.0186)	-0.0821*** (0.0183)
Communist Party member (using non-communists as reference)	-0.0445 (0.0890)	-0.284* (0.159)	-0.163 (0.232)	-0.0948 (0.256)
Ethnicity (using ethnic minorities as reference)	0.470*** (0.0994)	0.633*** (0.177)	0.104 (0.235)	0.142 (0.228)
Religious (using non-religious people as reference)	-0.0688 (0.0840)	-0.336*** (0.130)	-0.0441 (0.221)	-0.104 (0.201)
Rural household registration (using urban citizens as reference)	0.112* (0.0602)	-0.0847 (0.0983)	-0.00175 (0.155)	0.135 (0.159)
Constants	-0.229 (0.196)	-0.834*** (0.322)	-2.523*** (0.500)	-2.355*** (0.479)
Sample size	10,130	10,130	10,130	10,130

Standard errors are in parentheses

\*\*\* p&lt;0.01, \*\* p&lt;0.05, \* p&lt;

**Appendix4: Table 4. Analysis of consumption frequency of "going out to cinemas**

Independent variable	Daily	Several times a week	Several times a month	Several times a year
Eastern Region (using the western region as reference)	0.0502 (0.436)	2.539*** (0.469)	1.751*** (0.180)	0.644*** (0.0782)
Central Region (using the western region as reference)	-0.733 (0.475)	0.900* (0.514)	0.693*** (0.195)	0.259*** (0.0785)
Male (using women as reference)	-0.309 (0.367)	0.0858 (0.193)	-0.124 (0.0993)	-0.0138 (0.0565)
Age	-0.0267* (0.0143)	-0.0724*** (0.00848)	-0.0862*** (0.00468)	-0.0454*** (0.00221)
Years of Education	0.0618 (0.0569)	0.122*** (0.0337)	0.229*** (0.0186)	0.133*** (0.00936)
Annual income (ln)	0.0715 (0.0680)	0.0592* (0.0334)	0.0688*** (0.0165)	0.0229** (0.00908)
Communist Party member (using non-communists as reference)	-0.370 (0.765)	-0.153 (0.328)	0.141 (0.148)	0.266*** (0.0878)
Ethnicity (using ethnic minorities as reference)	-0.649 (0.506)	0.439 (0.442)	0.333 (0.224)	0.261** (0.108)
Religious (using non-religious people as reference)	-0.310 (0.496)	-0.864*** (0.250)	0.164 (0.185)	0.0441 (0.0953)
Rural household registration (using urban citizens as reference)	0.264 (0.437)	-0.592** (0.231)	-0.661*** (0.123)	-0.423*** (0.0648)
Constants	-4.155*** (1.284)	-3.782*** (0.851)	-3.228*** (0.446)	-0.963*** (0.217)
Sample size	10,119	10,119	10,119	10,119

Standard errors are in parentheses

\*\*\* p&lt;0.01, \*\* p&lt;0.05, \* p&lt;0

**Appendix 5: Table 5. Analysis of consumption frequency of  
"reading books/newspapers/magazines" consumption**

Independent variable	Daily	Several times a week	Several times a month	Several times a year
Eastern Region (using the western region as reference)	0.873*** (0.118)	0.471*** (0.101)	0.402*** (0.0910)	0.437*** (0.0859)
Central Region (using the western region as reference)	-0.192 (0.123)	-0.252** (0.102)	-0.214** (0.0891)	0.182** (0.0798)
Male (using women as reference)	0.496*** (0.0838)	0.313*** (0.0759)	0.270*** (0.0693)	0.190*** (0.0637)
Age	0.0143*** (0.00303)	-0.0122*** (0.00283)	-0.0231*** (0.00261)	-0.0227*** (0.00238)
Years of Education	0.332*** (0.0141)	0.320*** (0.0131)	0.270*** (0.0119)	0.175*** (0.0103)
Annual income (ln)	0.0254* (0.0143)	0.0486*** (0.0126)	0.0506*** (0.0111)	0.0266*** (0.00963)
Communist Party member (using non-communists as reference)	1.282*** (0.134)	1.154*** (0.133)	0.846*** (0.132)	0.448*** (0.138)
Ethnicity (using ethnic minorities as reference)	-0.344** (0.153)	-0.0756 (0.140)	-0.227* (0.120)	-0.00371 (0.110)
Religious (using non-religious people as reference)	-0.169 (0.133)	-0.310*** (0.119)	-0.0110 (0.113)	-0.0997 (0.100)
Rural household registration (using urban citizens as reference)	-1.470*** (0.0981)	-1.166*** (0.0858)	-0.934*** (0.0776)	-0.573*** (0.0721)
Constants	-4.611*** (0.326)	-2.994*** (0.293)	-1.854*** (0.262)	-0.986*** (0.236)
Sample size	10,110	10,110	10,110	10,110

Standard errors are in parentheses

\*\*\* p<0.01, \*\* p<0.05, \* p<0

**Appendix 6: Table 6. Analysis of consumption frequency of participation in cultural activities**

Independent variable	Daily	Several times a week	Several times a month	Several times a year
Eastern Region (using the western region as reference)	-0.634** (0.284)	0.0708 (0.194)	0.353*** (0.135)	0.0901 (0.0769)
Central Region (using the western region as reference)	-0.676** (0.275)	-0.781*** (0.228)	-0.368** (0.150)	-0.0827 (0.0772)
Male (using women as reference)	-0.491** (0.239)	-0.0967 (0.150)	-0.122 (0.0941)	-0.0919 (0.0563)
Age	0.000593 (0.00838)	-0.0186*** (0.00569)	-0.0205*** (0.00361)	-0.0217*** (0.00211)
Years of Education	0.0462 (0.0339)	0.132*** (0.0247)	0.173*** (0.0162)	0.126*** (0.00913)
Annual income (ln)	-0.0859*** (0.0293)	0.000820 (0.0235)	0.0669*** (0.0181)	0.0176* (0.00912)
Communist Party member (using non-communists as reference)	0.856*** (0.321)	0.287 (0.221)	0.0212 (0.141)	0.479*** (0.0833)
Ethnicity (using ethnic minorities as reference)	0.0430 (0.441)	0.985** (0.402)	0.0809 (0.194)	-0.109 (0.101)
Religious (using non-religious people as reference)	0.612 (0.477)	-0.814*** (0.204)	-0.384*** (0.147)	-0.143 (0.0922)
Rural household registration (using urban citizens as reference)	-0.651** (0.259)	-0.576*** (0.177)	-0.730*** (0.116)	-0.625*** (0.0645)
Constants	-3.825*** (0.863)	-3.683*** (0.613)	-3.333*** (0.379)	-1.087*** (0.211)
Sample size	10,126	10,126	10,126	10,126

Standard errors are in parentheses

\*\*\* p<0.01, \*\* p<0.05, \* p<0

**Appendix7: Table 7. Analysis of consumption frequency of  
"listening to music at home"**

Independent variable	Daily	Several times a week	Several times a month	Several times a year
Eastern Region (using the western region as reference)	-0.227** (0.104)	-0.141 (0.0894)	-0.427*** (0.0884)	-0.0351 (0.0878)
Central Region (using the western region as reference)	-0.715*** (0.105)	-0.600*** (0.0881)	-0.804*** (0.0870)	-0.245*** (0.0836)
Male (using women as reference)	-0.330*** (0.0785)	-0.199*** (0.0669)	-0.193*** (0.0679)	-0.109* (0.0644)
Age	-0.0441*** (0.00298)	-0.0486*** (0.00254)	-0.0391*** (0.00255)	-0.0262*** (0.00237)
Years of Education	0.190*** (0.0128)	0.150*** (0.0106)	0.135*** (0.0106)	0.0896*** (0.00952)
Annual income (ln)	-0.0125 (0.0117)	0.0251** (0.0107)	0.0385*** (0.0113)	0.0226** (0.0104)
Communist Party member (using non-communists as reference)	0.305** (0.124)	0.257** (0.111)	0.267** (0.111)	0.343*** (0.106)
Ethnicity (using ethnic minorities as reference)	-0.838*** (0.129)	-0.702*** (0.111)	-0.0796 (0.130)	0.0782 (0.125)
Religious (using non-religious people as reference)	-0.185 (0.125)	-0.424*** (0.101)	-0.0804 (0.112)	-0.0228 (0.105)
Rural household registration (using urban citizens as reference)	-0.894*** (0.0910)	-0.756*** (0.0767)	-0.781*** (0.0776)	-0.482*** (0.0730)
Constants	1.115*** (0.286)	1.788*** (0.244)	0.642** (0.259)	-0.0527 (0.249)
Sample size	10,104	10,104	10,104	10,104

Standard errors are in parentheses

\*\*\* p<0.01, \*\* p<0.05, \* p<

# Isolation, Identification, and Bioactivity of Four Bacillus Strains

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**Abstract:** To obtain the resources of bacillus which can be used in animal probiotics, plant biocontrol agents, and kitchen waste fermentation agents, four strains of Bacillus were isolated and screened from the soil, intestinal contents of healthy animals, feces, and natural water. The identified strains YBX06、YBX10 were *Bacillus thuringiensis*, and strain YBX08 were *Bacillus cereus*, Strain ybx15 is *Bacillus subtilis*. Through plate hydrolysis experiment, amylase production capacity was YBX08>YBX15>YBX10>YBX06; The protease production capacity was YBX10>YBX15>YBX08>YBX06; The esterase production capacity was YBX10>YBX08>YBX15>YBX06; The cellulase production capacity was YBX10>YBX06>YBX15>YBX08. The survival rate of YBX06 and YBX08 reached 90% after 3 hours of artificial gastric juice treatment; The survival rate of YBX10 was 91%; The survival rate of YBX15 was 96%. After artificial intestinal fluid treatment for 3 hours, the survival rate of YBX06 was 79%; The survival rate of YBX08 was 83%; The survival rate of YBX10 was 87%; The survival rate of YBX15 was 86%. The survival rates of the four strains were higher than 60% at 70 °C and 80 °C. The sensitivity of the four strains to the selected 10 commonly used antibiotics did not show universal resistance. The results showed that the four strains of Bacillus had the potential to be used in animal probiotics, kitchen waste fermentation, and plant biocontrol agents.

**Keywords:** Bacillus; Amylase; Cellulase; Protease; Esterase

## 1. Introduction

*Bacillus* sp. is a kind of aerobic or facultative anaerobic Gram-positive bacteria that widely exists in soil, water, air, and other environments [1], plant surface, rhizosphere, animal surface, and intestinal tract [2]. It can produce spores with strong resistance to high temperature, high pressure, acid-base, and some chemicals. At the same time, bacillus can produce amylase, cellulase, protease, and esterase with high activity [3]. At present, *B. subtilis*, *B. natto*, *B. licheniformis*, *B. cereus*, *B. lentus*, *B. circulans*, *B. firmus* and *B. megaterium* have been applied [4]. Some bacillus can be added to feed as probiotics. In 1996, the Ministry of Agriculture approved the use of 2 strains of feeding bacillus, and in 2013, the Ministry of Agriculture announced 6 strains of feeding bacillus. In 2018, the Ministry of agriculture and rural areas issued the supplement (Draft for comments) to the "feed additives catalogue (2013)", which intends to expand the scope of application of *Bacillus coagulans* and

divide the application of probiotics into four categories: *Bacillus* for livestock additives, bacillus for raw material fermentation, bacillus for aquaculture additives and bacillus for aquaculture waste treatment [5]. Compared with lactic acid bacteria, yeast, and photosynthetic bacteria, bacillus can withstand high temperature and high pressure without losing activity [6]. Ding Wenjun et al. (2016) showed that adding *Bacillus megaterium* 1259 to the diet of 300-day old Hailan Brown laying hens can improve production performance, increase profits, and have better ammonia and odor removal effect [7]. In addition, bacillus can antagonize intestinal pathogenic bacteria, plant pathogenic bacteria and plant pathogenic fungi, and replace antibiotics and antibiotics to a certain extent in the breeding industry. It is reported that there are as many as 55 kinds of genes and related active substances with antagonistic effect in *Bacillus*. The antagonistic mechanism is that the bacteria secrete a variety of low molecular weight antimicrobial peptides and bacteriocins [8-9]. A *Bacillus subtilis* isolated by Lin



min et al. (2017) has an antibacterial effect on *Staphylococcus aureus*, *erysipelas suis*, and *Streptococcus* [10]; *Bacillus subtilis* LF17 isolated from apple branches by Zhang Wuyun (2019) has a strong inhibitory effect on *Valse* spp., and has good control effect on *Fusarium*, *Alternaria* walnut and other pathogens [11]. As an enzyme-producing bacterium, bacillus has great potential in industrial and agricultural production. Wang Shuang and others (2017) isolated two alkaline protease-producing bacteria from Baijiu fermented grains, which could grow well in the medium containing 6% ethanol and produce a typical sauce flavor [12]. Li Hao (2019) isolated and screened a strain of *Bacillus subtilis* B17 with high cellulase production from humus soil, which can be used for both straw feed production and composting of crop straw waste [13]. The physical and chemical characteristics of different strains of *Bacillus* are different. In this study, four strains of *Bacillus* were isolated and screened from the soil, intestinal contents of healthy animals, feces, and natural water. The enzyme production ability, stress resistance ability, and antibiotic sensitivity of the strains were determined. The strains were identified by morphological, physiological, and biochemical methods and PCR. It lays a foundation for the development of biological products such as biocontrol bacteria and probiotics.

## 2. Materials and Methods

### 2.1 Materials

2.1.1 Separation materials: soil, intestinal contents of healthy animals, feces, and natural water

2.1.2 Test medium: nutrient agar medium, broth medium, LB agar

The medium for protease activity determination: casein 10g, peptone 10g, beef extract 5g, NaCl 5g, glucose 5g, agar powder 9.6g, pH 7.2, distilled water 1000ml, 121.3 °C 20min;

The medium for amylase activity determination: soluble starch 10g, peptone 10g, glucose 5g, NaCl 5g, beef extract 5g, agar powder 8g, pH 7.2, distilled water 1000ml, 121.3 °C, 20 min;

The medium for cellulase activity determination: CMC Na 10g, peptone 5g, yeast extract 0.5g, KH<sub>2</sub>PO<sub>4</sub> 1.5g, MgSO<sub>4</sub> 0.2g, NaCl 5g, agar powder 8g, pH 7.2, distilled water 1000ml, 121.3 °C, 20min;

The culture medium for esterase activity determination: tryptone 10g, yeast extract 5g, NaCl 10g, agar powder 12g, olive oil emulsion 10ml, 0.01g/ml rhodamine B 1ml, natural pH, 121.3 °C, 20min.

2.1.3 Quality control strains: *Escherichia coli*

(ATCC25922), *Staphylococcus aureus* (atcc25923), purchased from Sichuan industrial microbial strains preservation and management center.

2.1.4 Source of strain: an aseptic collection of soil, intestinal contents of healthy animals, feces, and other isolation materials. Aseptic operation: take a little of the material to be separated, transfer it into a test tube filled with 10ml sterilized distilled water, mix it well, and treat it in a boiling water bath for 10min. Take 1ml of the mixed bacteria solution after treatment, separate it on a nutrient agar medium plate, and incubate it at 32 °C for 24h until the pure culture is obtained. The pure culture is transferred to the slope of the nutrient agar medium and incubated at 32 °C for 24h, then it is transferred to a 4 °C refrigerator for storage.

Four strains were isolated and identified as YBX06、YBX08、YBX10、YBX15.

### 2.2 Test method

2.2.1 Determination of enzyme production capacity [14]

Strain activation: the tested strains were inoculated in broth medium, incubated at 32 °C for 24 hours, and used for standby.

Xinhua No.1 qualitative filter paper was used to make a circular filter paper with a diameter of 3 mm, which was placed in a culture dish and sterilized at 121 °C under high temperature and high pressure; In aseptic operation, put the sterilized paper into the center of the enzyme activity test plate medium, and press it gently close to the surface of the medium.

The active strains to be tested were dipped in a new culture dish with an inoculation ring, inoculated on the central sterile filter paper of each enzyme determination plate medium, and cultured at 32 °C for 24h to determine the activities of amylase and protease; After incubation at 32 °C for 48 h, the activities of esterase and cellulase were determined. Three repetitions were set for each.

Amylase activity determination: 1 ml Lugol's iodine solution was added to the amylase determination medium, and the colony diameter (d) and transparent circle diameter (D) were measured by vernier caliper, and the  $D/d$  value was calculated to determine the amylase production capacity of the strain.

Protease activity test: 1 ml of 5% trichloroacetic acid was added to the protease test medium, and the colony diameter (d) and transparent circle diameter (D) were measured by vernier caliper, and the  $D/d$  value was calculated to determine the protease production capacity of the strain.

Esterase activity determination: the hydrolysis

circle size was observed directly on the esterase activity determination plate, the colony diameter (d) and transparent circle diameter (D) were measured by vernier caliper, and the D / d value was calculated to determine the esterase production capacity of the strain.

Determination of cellulase activity: the cellulose plate was dyed with 0.2% Congo red for 30 minutes, and then the dyeing solution was washed out with distilled water and 1 mol / l NaCl, and then the color was fixed with 5% (w / V) acetic acid solution. The staining circle was formed around the colony, which proved that the bacterium secreted cellulase. The diameter of the colony (d) and the diameter of the transparent circle (D) were measured by vernier caliper, and the ratio of D / d was calculated to determine the cellulase activity of the strain.

2.2.2 Tolerance test: select the nutrient agar of the tested strain at 32 °C for 24 h, inoculate the slant culture into 100 ml broth medium, incubate at 32 °C for 56 h, and then treat at 90 °C for 15 min to kill the vegetative body in the culture medium to obtain Bacillus suspension.

The number of spores in spore suspension was determined by the dilution plate method.

Study on tolerance of artificial gastric juice and artificial intestinal juice: artificial gastric juice preparation: take 10% hydrochloric acid 16.4ml, dilute with distilled water, pH value is 2.0, add 1g pepsin into every 100ml solution, fully dissolve, and filter with 0.22µm microporous membrane.

Preparation of artificial intestinal juice: take 46.8g KH<sub>2</sub>PO<sub>4</sub>, add 500ml distilled water to dissolve, adjust the pH value to 6.8 with 0.4% NaOH solution, add 1000ml distilled water, add 1g trypsin into every 100ml solution, dissolve fully, and then filter with 0.22µm microporous membrane to remove bacteria.

1 ml of spore suspension was transferred into 10 ml of artificial gastric juice and 10 ml of artificial intestinal juice respectively. After shaking and mixing, the spore suspension was incubated in a 32 °C water bath for 3 h, and the spore number was determined by dilution plate method every 0.5 H.

The survival rate of spores in artificial gastric juice (%) = number of spores after incubation with artificial gastric juice/number of spores \* 100

The survival rate of spores in artificial intestinal juice (%) = amount of spores/number of spores \* 100

Heat resistance test: take 1ml of the above 32 °C 56h culture medium, add it into 100ml sterilized normal saline, shake, and mix well, respectively put it in the water bath at 32 °C, 70 °C, 80 °C, 90 °C and 100 °C for

15min, put it on ice to cool quickly, and measure the number of live bacteria by dilution plate.

Survival rate at different temperatures (%) = number of viable bacteria after water bath treatment at different temperatures/number of viable bacteria after water bath treatment at 32 °C \* 100.

2.2.3 Antibiotic sensitivity test: select the nutrient agar slant culture of the strains to be tested at 32 °C for 12h, select a small amount of culture, put it in sterilized distilled water, mix it well, and prepare the bacterial suspension.

The bacteria suspension was dipped with a sterilized cotton swab and evenly coated on a nutrient agar plate. Take the commercially available drug-sensitive paper, respectively, close to the surface of the medium, put it in the constant temperature incubator at 32 °C for 24 hours, and then measure the diameter of the inhibition zone.

1.2.4 identification of strains: morphological observation: the tested strains were inoculated on a nutrient agar plate at 32 °C for 24h, and the morphological characteristics of colonies were observed; The edge culture of the colony was picked out, Gram staining and microscopic examination were used to observe the morphological characteristics of the bacteria.

Physiological and biochemical tests:

According to Berger's bacterial system manual [15] and common bacterial System Identification Manual [16], gelatin liquefaction, contact enzyme, V-P reaction, indole reaction, citrate utilization, urea utilization, glucose utilization, xylose utilization, mannitol utilization, arabinose utilization, hippurate hydrolysis, arginine double hydrolysis, casein hydrolysis, tyrosine hydrolysis, starch hydrolysis, Nitrate reduction, phenylalanine dehydrogenase, 2% NaCl growth, 5% NaCl growth, 7% NaCl growth and other physiological and biochemical indicators were tested.

16S rRNA sequence analysis: the tested strains were cultured on LB medium at 32 °C for 24 h, and shaking at 180 rpm at 28 °C for 12 h. The total DNA was extracted as a template. The PCR amplification was performed with the universal primers 27F:5'-AGAGTTTGATCCTGGCTCAG-3, 1492R: 5'-TACGGCTACCTTGTTACGACTT-3.

PCR reaction system: 25 µL, ddH<sub>2</sub>O 8 µL, PCR MIX 12 µL, 27F 1 µL, 1492R 1 µL, Template DNA 3 µL.

The PCR procedure was as follows: pre denaturation at 94 °C for 4 min, denaturation at 94 °C for 30 s, annealing at 52 °C for 30 s, extension at 72 °C

for 1 min, 30 cycles, final extension at 72 °C for 10 min and storage at 4 °C.

PCR products were sent to Shanghai Shengqong biology Co., Ltd. for sequencing. The 16S rDNA sequences were submitted to NCBI nucleic acid database for BLAST online homology comparison. Multiple sequence alignment analysis was performed by MEGA X, and the phylogenetic tree of each strain was constructed by the neighbor-joining (NJ) method.

### 3. Results and Analysis

#### 3.1 Determination of enzyme production capacity

The four strains could grow normally on the medium of amylase, protease, esterase, and cellulase activity determination, and produced hydrolysis circles of different sizes. The activity of YBX08 amylase was the strongest, and that of YBX10 protease, esterase, and cellulase was the strongest (See Appendix 1: Fig.1).

#### 3.2 Tolerance test

3.2.1 Study on tolerance of artificial gastric juice and artificial intestinal juice spores of four strains were treated with artificial gastric juice and artificial intestinal juice for 3 h. The survival rates were shown in Table 1 (See Appendix 2) and table 2 (Appendix 3). The four strains of *Bacillus* showed strong tolerance to artificial gastric juice and intestinal juice, which indicated that the four strains of *Bacillus* should be able to pass through the animal stomach and intestines and enter the middle and posterior digestive tract.

3.2.2 Heat tolerance test: the survival rates of spores of four strains after water bath at 70 °C, 80 °C, 90 °C, and 100 °C are shown in Table 3 (See Appendix 4). The survival rates of the four strains were higher than 60% at 70 °C and 80 °C.

The sensitivity of 4 strains to 10 antibiotics is shown in Table 4 (See Appendix 5), and the sensitivity to the 10 commonly used antibiotics selected is not generally resistant.

All strains put into the environment will not lead to the spread of drug resistance [18].

#### 3.4 Strain identification

3.4.1 Morphological observation: the tested strains were inoculated on the nutrient agar plate at 32 °C for 24 h. The morphological characteristics of the observed colonies are shown in Table 5 (See Appendix 6).

Gram-positive bacteria were detected by Gram staining. YBX06, 08, and 10 were arranged in chains, and the spores were nearly mesophytic and slightly expanded. YBX15 is solitary, the spores are mesophytic and not

swollen.

#### 3.4.2 Physiological and biochemical identification

See Table 6 (Appendix 7) for the results of physiological and biochemical tests.

According to the results of morphological observation and physiological and biochemical identification, according to Berger's bacterial system manual [15] and common bacterial System Identification Manual [16], YBX06 and YBX10 were identified as *Bacillus thuringiensis*, YBX08 as *Bacillus cereus* and YBX15 as *Bacillus subtilis*.

3.4.3 16S rRNA sequence analysis: genomic DNA of YBX06, YBX08, YBX10, and YBX15 were extracted as templates to amplify the 16S rDNA gene, and a PCR characteristic band of about 1500kb was obtained and sequenced. The sequencing results were uploaded to GenBank and compared with the known sequences in GenBank by BLAST. Similar reference strains were selected, and the phylogenetic tree was constructed by the NJ method using MEGA X software to determine the phylogenetic.

The similarity between YBX06 (GenBank accession number: MT422211) and *B. thuringiensis* (GenBank accession number: MG738336.1) 16S rRNA was 99%; The similarity between YBX08 (GenBank accession number: MT427643) and *B. sp. .* (GenBank accession number: MK479931.1) 16S rRNA was 99%; The similarity between YBX10 (GenBank accession number: MT427644) and *B. thuringiensis* (GenBank accession number: KF935650.1) 16S rRNA was 99%; The similarity between YBX15 (GenBank accession number: MT427735) and *B. thuringiensis* (GenBank accession number: AB986572.1) 16S rRNA was 99%. The phylogenetic tree is shown in Figure 2 (See Appendix 8).

### 4. Discussion and Conclusion

*Bacillus* sp. is a kind of Gram-positive bacteria widely existing in the environment, which can produce amylase, protease, esterase, cellulase, Ligninase, and chitinase; And its spores have strong resistance to high temperature, high pressure, and strong acid. In addition, bacillus has become an important research target in scientific research and production practice due to its large population, strong fecundity, and stable physical and chemical properties [19]. What's more, bacillus has simple nutritional requirements and fast growth speed, which makes the cost of production and fermentation lower. A large number of bacillus can also produce a

variety of secondary metabolites, which is an important source of antibacterial active substances [20-21]. It has related application research in animal breeding, health care, environmental pollution control, remediation, and biological control of crop diseases and pests [22-26].

In this study, four strains of *Bacillus* were isolated and screened, which could produce amylase, protease, esterase, and cellulase. Through plate hydrolysis experiment, amylase production capacity was YBX08>YBX15>YBX10>YBX06; The protease production capacity was YBX10>YBX15>YBX08>YBX06; The esterase production capacity was YBX10>YBX08>YBX15>YBX06; The ability of cellulase production was YBX10>YBX06>YBX15>YBX08. At the same time, four strains of *Bacillus* were determined to be sensitive to commonly used antibiotics, and the application in the environment would not cause the spread of drug resistance genes. YBX06 and YBX10 were identified as *B. thuringiensis* and YBX08 as *Bacillus cereus*. YBX15 is *Bacillus subtilis*. The four strains of *Bacillus* have the potential to be used in animal probiotics, kitchen waste fermentation, and biocontrol agents. In the follow-up study, the enzyme production capacity of the above strains will be determined in more detail, and the culture conditions will be optimized to further improve their enzyme production capacity. Existing studies have shown that in the practical application of biological agents, whether it is animal probiotics, plant biocontrol agents, kitchen waste treatment microbial agents, compared with a single strain, the composite strains composed of strains with different characteristics have better application effect [27-30]. The acquisition of the corresponding strains in this study prepared the strain resources for the later research of compound bacteria. Based on the further exploration of strain resources, the biological characteristics of the obtained strains and the biological characteristics of different combinations were studied, and the application direction was determined.

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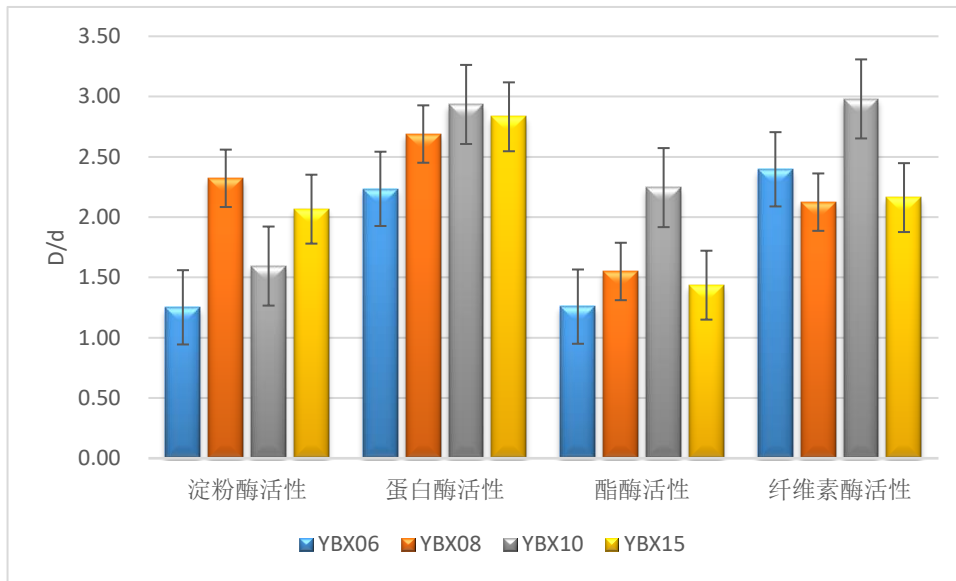
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**Appendix 1: Figure 1. Enzyme production capacity**



**Appendix 2: Table 1. Artificial gastric juice tolerance (spore survival rate%)**

Strains	Time(h)					
	0.5	1.0	1.5	2.0	2.5	3.0
YBX06	98	96	95	93	92	90
YBX08	96	95	95	95	94	90
YBX10	99	97	96	96	95	91
YBX15	100	100	98	97	96	96

**Appendix 3: Table 2. Artificial intestinal fluid tolerance (spore survival rate%)**

Strains	Time(h)					
	0.5h	1.0h	1.5h	2.0h	2.5h	3.0h
YBX06	86	84	84	82	81	79
YBX08	88	87	87	87	86	83
YBX10	95	93	92	92	91	87
YBX15	91	90	90	87	87	86

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**Appendix 4: Table 3. Heat Resistance (Survival%)**

Strains	Temperature (°C)			
	70	80	90	100
YBX06	76	67	33	16
YBX08	75	67	50	32
YBX10	77	68	59	18
YBX15	77	69	46	38

**Appendix 5: Table 4 Antibiotic sensitivity**

Strains	YBX06		YBX08		YBX10		YBX15	
	Bacteriostatic circle(mm)	sensitivity	Bacteriostatic circle(mm)	sensitivity	Bacteriostatic circle(mm)	sensitivity	Bacteriostatic circle(mm)	sensitivity
Erythromycin	21.2±1.4	medium	24±2.42	high	20.9±1.65	medium	23±1.66	high
Ampicillin	10.1±1.68	low	0±0	low	0±0	low	7.8±0.72	low
Ciprofloxacin	20±1.93	medium	22±4.42	medium	19.8±0.3	medium	22±0.53	medium
Gentamicin	17.9±0.79	medium	18.4±3.6	medium	17.7±0.72	medium	20.3±0.26	medium
Amikacin	21.3±1.11	high	24.2±4.68	high	21±0.72	high	23.1±0.44	high
Penicillin	3.4±0.87	low	0±0	low	0±0	low	0±0	low
Vancomycin	13±1.91	low	11.5±0.	low	12.9±0.	low	16.3±1.	medium

**Note:** the sensitivity standard part refers to the isolation and identification of *Haemophilus paragallinarum* Guizhou strain by Lin Hanqing (2018) [17].

**Appendix 6: Table 5 Colony morphology of Bacillus**

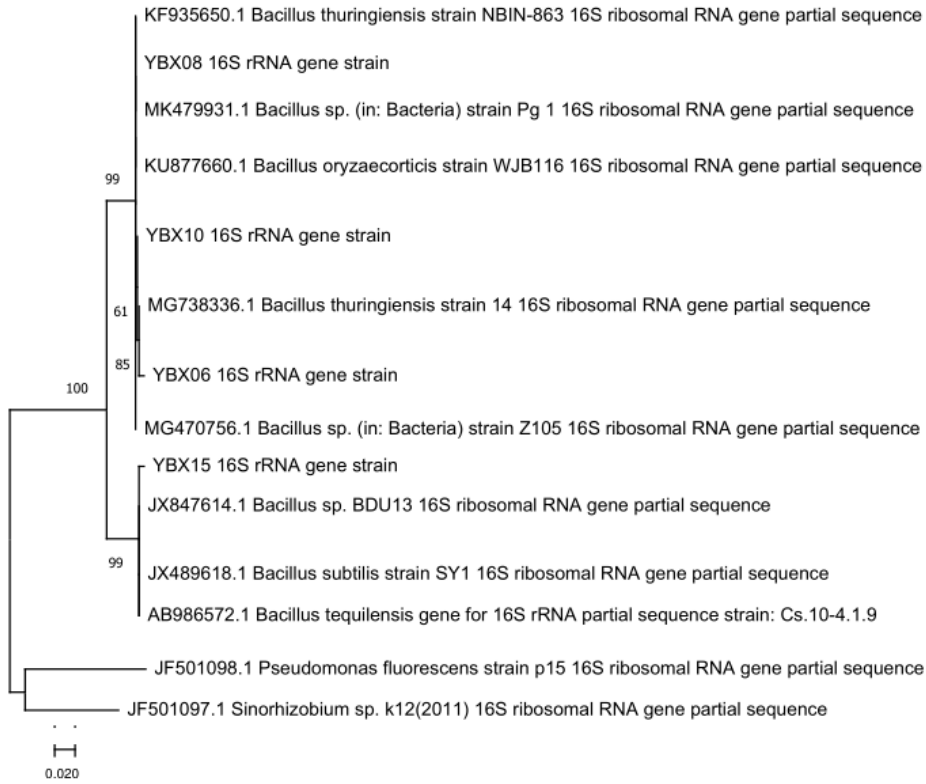
Strains	Morphological description
YBX06	Colony slightly raised, yellowish, opaque, waxy, radiant wrinkled, pigment free
YBX08	Colony flat, gray white, opaque, waxy, radiant wrinkle on the surface, no pigment
YBX10	Colony slightly raised, yellowish, opaque, waxy, radiant wrinkled, pigment free
YBX15	Colonies slightly raised, milky white, rough and dry, irregular wrinkles and no pigment on the surface

**Appendix 7: Table 6. The physiological and biochemical characteristics of four *Bacillus* strains****Note:** Note "+" is positive and "-" is negative

Strain characteristics	YB X06	YB X08	YB X10	YB X15	Strain	YB X06	YB X08	YB X10	YB X15
					characteristics				
Gelatin liquefaction	+	+	+	+	Hippurate hydrolysis	-	-	-	-
Hydrogen peroxide	+	+	+	+	Arabinose	+	+	+	+
Voges-Proskauer reaction	+	+	+	+	Casein	+	+	+	+
Indole production	-	-	-	-	Tyrosine	+	+	+	+
Citrate	-	-	-	-	Amylase	+	+	+	+
Propionate	-	-	+	-	Nitrate reduction	+	+	+	+
Urease	-	-	-	-	Phenylalanine	+	-	-	-
Glucose	+	+	+	+	2% Sodium chloride	+	+	+	+
Xylose	+	+	-	-	5% Sodium chloride	+	+	+	+
Mannitol	+	+	+	+	7% Sodium chloride	+	+	+	+



**Appendix 8: Fig. 2. The neighbor-joining tree based on 16S rRNA**



# Applying Paperless Digital Slice Examination Model in Histology Experiment Assessment of Chinese Medical Specialty

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**Abstract:** The traditional histology experiment assessment has some shortcomings, such as difficulty in making test slices and restricted test scope. Its test questions are often single, dull, one-sided in the assessment of students, and the test organization process is long and complicated. To overcome the recognized limitations of traditional assessment, the author with her teaching and research team combined the network examination software, digital slice library and digital microscopy interactive system, and established a paperless digital slice examination model, and applied the model to the examination of histology experiments in Chinese medicine majors. This paper is a report of teaching research exploring the use of the new assessment model in histology teaching at the School of Medicine, Yanbian University, China.

**Key words:** Paperless examination, histology experiment assessment, undergraduate teaching, digital slice, Chinese medical specialty

## 1. Introduction

In recent years, computer-aided evaluation and assessment have been widely used in the process of educational measurement and learning assessment, which has triggered profound changes in the content, methods, and forms of evaluation and assessment. Applying an online evaluation and assessment system that combines educational evaluation and assessment theory, methods, and modern information technology to provide students with "flexible, convenient, scientific and fair assessment services" is an important mission faced by educators<sup>[1]</sup>. Our research on the digital slice examination model was carried out in this context. We recognized that the traditional histology experiment assessment had some shortcomings, such as restricted examination scope and difficulty in preparing test specimens. There are phenomena such as single-type examination questions, dullness, and one-sided assessment of students. Moreover, the test organization process is relatively long. From the aspects of the proposition, paper making, issuing, guaranteeing, examination, marking, entering scores, publishing scores, etc., the process is more complicated, and there are problems with security and confidentiality in any of the links, and the consequences would be very serious.

Traditional assessments have higher requirements for invigilators, and their work is also very difficult. In addition, to follow a correct operation, it is challenging to deal with cheating in exams<sup>[2]</sup>.

To overcome the recognized limitations of traditional assessment, the digital slice examination system is explored as a model formed by our teaching and research team to combine network examination software, digital slice library, and digital microscopy interactive system. That is to say, a large number of digital slice specimens are randomly organized through the network test software, and the test questions are designed, and the students participate in the test through the digital microscope interactive system, and the teacher "monitors" the student's answering process. The digital slice test model overcomes the shortcomings of the previous experimental test model, greatly shortens the test cycle, improves safety, and can more objectively, truthfully, fairly, and comprehensively examine the students' understanding of the knowledge learned, thereby further improving the teaching effect<sup>[3]</sup>. Recently our teaching and research team has established a digital slice examination system through the combination of digital slice library, and digital micros. We also have applied this model to the histology experiment assessment of the Chinese medicine

specialty and would like to discuss the role of the model in the teaching of histology in this paper.

## **2. Methods of Production of Histology Experiment Assessment Software**

### **2.1 Selection of assessment content**

First, we selected the organs, tissues, structures, and cells in the tissue section to be assessed, and grouped them into different groups according to the degree of difficulty. Then we used a microscope with a camera connected to a computer to adjust the brightness, field of view, focal length of the tissue section, etc. Generally, we chose high power (400 times) for cells, low power (100 times or 200 times) for tissues, and low power (40 times) for organs. Based on the organization and structure display clearly, we determined the magnification and shoot and saved it in the computer in the form of a JPG file. For the same organ tissue, we took multiple angles and multiple fields of view, stored pictures, and established a digital slice library.

### **2.2 Production of assessment software**

Using PowerPoint software, we clicked the "New Slide" button, and selected a blank layout to add a blank slide. Then we copied and pasted the pictures in the established digital slice library into the slides randomly according to the test content and adjust the size of the pictures. Next, we clicked the "Text Box" button to add numbers and ask questions in the corner of the graph. After then, we brought up the "Drawing" toolbar and used arrows and other tools to mark the picture. We Repeated the above operation to create the remaining slides, and then set the time for the slide show, added the number, the voiceover of the question, and finally saved it. After the complete set of assessment software was completed, we made multiple sets of test questions according to the number of people in the test, and the content could be repeated appropriately according to the key points to preventing the test questions from leaking.

## **3. Application and Effect of Histology Experiment Assessment Software**

In the histology experiment assessment of Chinese medicine majors, our teaching and research team used the histology assessment software for experimental assessment. We found that this paperless digital slice examination model has many advantages during application: (1) In the experiment during the teaching process, students observe the sliced specimens through the computer screen connected with the microscopic interactive system. Therefore, compared with the traditional assessment method, this digital slice

examination system model is more suitable for assessing students' understanding of the knowledge they have learned, and further improving the teaching effect. (2) There is no need for teachers to place the microscope and look for the structure under the mirror, which saves a lot of manpower and material resources. (3) Without using a microscope, there is no possibility of moving the sliced specimens. Students can view the pictures of cells, tissues, structures, and organs through the computer screen of the student terminal. The pictures are clear, and the positioning is accurate, and the examination process is controlled by the teacher through the teacher's computer. (4) Multiple sets of test questions of the same difficulty or different levels of difficulty were prepared on the computer at the same time. Students of different groups can take the test in class, avoiding the possibility of test questions leaking, which could improve teaching efficiency, and ensure the fairness and accuracy of the test. (5) Compared with other professional histology experimental assessment results, the new assessment method has improved students' achievement significantly.

## **4. The Results, and Issues for Further in-depth Study**

### **4.1 Major achievements**

Through the combination of a digital slice database, digital microscopy interactive system, and office software, a digital slice examination system has been established, and this model has been applied to the assessment of histology experiments for students of Chinese medicine. The application of this examination system can overcome the shortcomings of traditional experimental assessment methods, and can be more objectively, truly, and comprehensively examine the degree of students' understanding of the knowledge they have learned, thereby further improving the teaching effect, and providing an important role in the organization of courses of Chinese medicine majors. It also provides effective teaching reform programs and can provide theoretical and practical experience for other related disciplines to carry out digital examinations. The digital slice examination system model fully embodies the application of modern education and teaching methods. It is more random in terms of time and space, and more choices in test question design, so that the content of the test can be expanded in breadth and depth to the greatest extent. The objectivity, fairness, and authenticity of the examination can effectively improve the teaching effect.

### **4.2 Innovations**

(1) Random in space and time: Students can take the test at any time on any computer in the classroom within the prescribed test time. If a computer has a problem, the student can immediately change to another computer, thus can reduce the space and time constraints causing pressure on students and allowing students to play freely.

(2) Save a lot of manpower and material resources: Compared with traditional assessment methods, this method does not require a large number of proctors. In addition, this method does not have the possibility of moving the slices. Students watch the pictures through the computer screen, the pictures are clear, and the positioning is accurate.

(3) The content of the exam is random and personal information is confidential: The exam software is equipped with a password and a password module, which has a unitary nature and can keep the students' privacy confidential. In addition, in the question bank module of the software, we have prepared multiple sets of test questions of different difficulty or the same difficulty before the test. Students in different groups can be randomly selected to avoid the possibility of test

questions leaking and ensure the accuracy and fairness of the test.

#### 4.3 Issues that need to be further studied

The digital auxiliary examination system is based on the computer system, so the daily maintenance and system upgrade of the computer and other hardware facilities require special personnel and special expense support.

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# On Teaching Reform of the Experiment Course of Histology Digestive Tube for Clinical Medicine Majors

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**Abstract:** Histology is one of the compulsory courses of clinical medicine, and it is also a basic medical course. The prerequisite courses for studying histology are human anatomy and medical cell biology, and the post-requestion courses are physiology and pathology, and clinical medicine courses. The connection between these medical courses is very close. This paper is a report of the teaching research from the author's teaching and research team, who has carried out teaching reforms in the experiment course of histology digestive tube for clinical medicine majors, and we implemented a combination of flipped classrooms and hands-on experiments. The results of the research have been notable, which has effectively stimulated students' interest in learning and their ability to learn independently.

**Keywords:** Clinical medicine, histology experiment, teaching reform, flipped classrooms, hands-on experiments

## 1. Introduction

Histology is one of the compulsory courses for medical majors, and it is also a basic medical course. The course is closely related to other basic medical courses such as human anatomy, physiology, pathology, etc., and it is also a clinical medicine course, which is an important basic course. Histology is the first medical basic course for freshmen of clinical medicine. The teaching content of histology is rich, abstract, and boring. Therefore, how to improve students' interest and ability in learning histology is an issue that teachers of histology need long-term research. Based on this understanding, we used a combination of flipped classrooms and hands-on experiments in the teaching of the digestive tract organization experimental class, which proved that the teaching reform method can improve students' interest and ability in learning. The results of the research are now reported as follows.

## 2. Reform of the Teaching of the Course of Digestive Tract Experiment

### 2.1 Flipped classroom

The flipped classroom is to complete the teaching of knowledge by watching videos before class, and teachers internalize student knowledge through various teaching methods in the classroom. There are various forms of teaching videos, including multimedia such as

slides, audios, and micro-classes. In the flipped classroom, the traditional teaching is replaced by activities such as experiments and classroom discussions<sup>[1]</sup>. We choose parts that are less difficult and easy to master, such as the digestive tract chapter, for flipped classrooms, that is, role swaps, students are the speakers, teachers are guides, teachers prepare course materials, publish tasks through the Internet in advance, and students' study independently before class, In class, students discuss and show in groups, and the teacher summarizes after class. In accordance with the professional characteristics of clinical medicine, the teacher publishes 1-2 clinical cases related to the contents of the digestive tract chapters to students in accordance with the requirements of the syllabus of the histology course, allowing students to consult the Internet or book materials to find answers, discuss and analyze in class, and teachers will You can contact the content of histology to further explain the morphology, structure and function of tissue cells, and the pathophysiological changes of these tissue cells that occur in these disease states.

### 2.2 Hands-on experiment

#### 2.2.1 Experimental animals

Wistar rats (male or female, weighing 220-250 grams, provided by the Experimental Animal Center of Yanbian University) were used in this experiment.

#### 2.2.2 Hands-on experiment design and student

grouping

Taking 90 minutes of experimental class time as the standard, the experimental teaching assistants who cooperate with the teaching prepare rat stomach tissue slices in advance, the purpose is to save class time, arrange students' experimental procedures tightly, and avoid idle periods in class. Students are divided into 4 groups with 7-8 people in each group. Four hands-on experiments are carried out based on the teacher's scientific research direction, including 3 dyeing methods and one functional experiment.

### 2.2.3 Experimental operation steps

#### 2.2.3.1 The first group

Preparation of experimental reagents:

Semi-oxidized hematoxylin dye solution: 2.36g of hematoxylin, fully dissolved in 250ml of ethylene glycol, add 750ml of distilled water to heat, then dissolve 0.2g of sodium iodate and 17.6g of potassium aluminum sulfate, filter and add 20ml of glacial acetic acid after cooling. 0.5% eosin dye solution: 1.5g eosin is dissolved in 300ml distilled water.

The sections were stained with hematoxylin and eosin (H&E), and the staining effect of the stomach histology was evaluated with an optical microscope to observe the structural characteristics of the stomach tissue.

#### 2.2.3.2 The second group

Masson's trichrome staining was performed to observe the fibrosis of gastric smooth muscle and the fiber composition in gastric tissue related to gastric motility disorders. (1) The sections are routinely deparaffinized to water and stained with the prepared Weigert iron hematoxylin for 5-10 minutes.

(2) Differentiate with acidic ethanol differentiation solution and wash with water.

(3) Use Masson blue liquid to return to blue and wash with water.

(4) Wash with distilled water for 1 min.

(5) Stain with Ponceau red fuchsin staining solution for 5-10 minutes.

(6) During the above operation, prepare a weak acid working solution according to the ratio of distilled water: weak acid solution = 2:1, and wash with the weak acid working solution for 1 min.

(7) Wash with the phosphomolybdic acid solution for 1-2 minutes.

(8) Wash with a prepared weak acid working solution for 1 min.

(9) Dye directly with aniline blue dye solution for 1-2 minutes.

(10) Wash with a prepared weak acid working

solution for 1 min.

(11) 95% ethanol is quickly dehydrated. Anhydrous ethanol is dehydrated 3 times, 5-10s each time.

(12) Xylene is transparent 3 times, 1-2min each time. Sealed with neutral gum.

2.2.3.3 The third group: ICC immunofluorescence staining of gastric smooth muscle.

The rats were sacrificed by decapitation, the stomach tissue was taken by laparotomy and the mucosa and submucosa were removed by dissecting with ophthalmic scissors in a Krebs solution of gassed (95% O<sub>2</sub> and 5% CO<sub>2</sub>) with the following components (mM): NaCl 118.5; Chlorination Potassium 4.5; Magnesium Chloride 1.2; NaHCO<sub>3</sub> 23.8; KH<sub>2</sub>PO<sub>4</sub> 1.2; Glucose 11.0; Calcium Chloride 2.4. Stretch the gastric smooth muscle tissue to 110% of its resting length and fix it with 4% ice-cold paraformaldehyde for 60 minutes. The tissue was then washed in 0.1 M phosphate-buffered saline (PBS) at 4°C overnight. The tissue was incubated in PBS containing 10% normal goat serum for 2 hours at room temperature to block non-specific binding. Then, the tissue was incubated with rabbit anti-c-KIT antibody mixed with Triton-X100 at 4°C for 48 hours. The samples were then washed in 0.1 M PBS at 4°C overnight and incubated with Alexa Fluor 488-conjugated goat anti-mouse IgG for 2 hours at room temperature. After washing, the tissue is mounted on a glass slide with an anti-fading agent, and images are acquired on a fluorescence microscope to observe the distribution and morphology of ICC related to gastric motility disorders.

2.2.3.4 The fourth group: the preparation of gastric smooth muscle strips and the measurement of isometric tension

The rats were killed by decapitation, and the stomach was quickly removed and placed in oxygen-saturated Krebs solution (mmol/L: NaCl 118, KCl 4.75, CaCl<sub>2</sub> 2.54, KH<sub>2</sub>PO<sub>4</sub> 1.19, MgSO<sub>4</sub> 1.19, NaHCO<sub>3</sub> 25, Glucose 10) below 4°C. Cut along the lesser curvature of the stomach and rinse out the stomach contents. Carefully cut off the mucosal layer and cut a 2×12mm circular muscle strip along the direction of the gastric antral circular muscle fiber at 5mm from the proximal end of the pylorus. The removed muscle strip is placed in a vertical perfusion tank with Kerb's solution, one end is fixed on a platinum wire hook, and the other end is connected with a tension transducer. The temperature in the perfusion tank is maintained at 37°C with a constant temperature water bath and continues to Supply a mixed gas of 5% CO<sub>2</sub> and 95%

O<sub>2</sub>. Apply 1g of tension to the tissue, balance for 40-60 minutes, measure muscle strip movement through the RM-6240 multi-channel physiological signal recording system and ask students to combine other three groups of morphological observations to think about the principle of spontaneous contraction of gastric smooth muscle.

### 3. Discussion

Histology is one of the compulsory courses for medical majors, and it is a basic medical course. The prerequisites for histology are human anatomy and medical cell biology, and the latter courses are physiology and pathology. Histology and clinical medicine courses, and other basic medical courses are closely linked.

The essence of the flipped classroom is to shift from passive learning to active learning. Active learning pays attention to the stimulation of the intrinsic motivation of learning, emphasizes the "doing" or "activity" of students in the learning process, and pays attention to the role of students in the classroom teaching process [2]. Studies have shown that flipped classrooms effectively improve students' academic performance and stimulate their interest in learning.

In recent years, many colleges and universities have also carried out experimental teaching reforms by carrying out student hands-on experiments such as making tissue specimens. Research has found that hands-on experiments can not only improve students' hands-on operation ability but also transform test-oriented education to quality education [3].

In latest years, our teaching and research team has implemented a small class teaching model. This teaching model is conducive to grouping students to conduct hands-on experiments. The digestive tract chapter mainly describes the esophagus, stomach, small intestine, large intestine, etc., among which the cell and fiber components in the stomach tissue are compared. Many and complicated, so this hands-on experiment takes gastric tissue specimens as the starting point, which can not only enrich the content of histology, connect teaching and scientific research naturally, but also achieve the purpose of improving the quality of experimental teaching, turning passive acceptance of

learning into active autonomous learning enables students to better grasp the morphological structure and distribution classification of the fibers and cells they are studying and also enables students to further understand the functions of these cells and fibers, and the relationship between these cells and fibers and some related diseases.

In summary, with the development of informatization, flipped classrooms have been widely used in China and across the world, and have become one of the indispensable teaching methods for teachers. In this study on the teaching reform of the digestive tract experiment course, the implementation of the combination of histology digestive tract flipping class and hands-on experiment has achieved remarkable results. The flipped classroom has effectively stimulated students' independent learning ability and interest in learning; the hands-on experiment has transformed the abstraction of the theory into specificity, students can clearly distinguish the structure and meaning represented by eosinophilia and basophilia, the close relationship between structure and function, and the relationship with related diseases. Therefore, the implementation of the experimental teaching reform combining class teaching and practical experiments makes students' learning enthusiastic and enables them to better understand and master the content of learning, which not only achieves the purpose of improving the quality of teaching and experiment teaching, but also achieves the quality of teaching, and the combination of teaching and research.

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