Volume 25
Number 02
December, 2024

SIEF

science insights education frontiers

pISSN: 2644-058X eISSN: 2578-9813

Published Monthly by
Insights Publisher

Science Insights Education Frontiers

pISSN 2644-058X
eISSN 2578-9813
(Monthly)

Volume 25, No. 2

December 2024

Insights Publisher

Science Insights Education Frontiers

pISSN 2644-058X
eISSN 2578-9813

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COMMENTARY

Reading Ability Development in Children: Key Factors and the Role of the Teachers' Reading Instruction Competence

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"Once you learn to read, you will be forever free."
-Frederick Douglass

IN MODERN society, reading ability is deemed the bedrock of student learning and lifelong education. Reading is crucial for information acquisition, intellectual development, and social development of the individual. Research shows that reading ability is not innate but rather the result of an ongoing educational process, in which early reading education plays a critical role (Shu & Li, 2014). Hulme and Snowling (2011) emphasized that a primary objective of early education is to teach the child how to read accurately and fluently with optimal comprehension of reading materials as reading is the paramount instrument for knowledge development in formal schooling. The reading skills developed in childhood and the low grades in the primary school have long-term effects on future learning outcomes (Mwoma, 2017). Hence, both parents and schools place a high value on child reading education.

Earlier research finds that among children with normal intelligence and comparable educational opportunities, 5%-10% of them still have the risk of suffering developmental dyslexia, irrespective of the language contexts. (Cunningham & Stanovich, 1997; Shu & Li, 2014). To address this issue, educational researchers have conducted extensive studies of the factors that may influence reading ability development of the child. First off, many studies suggest that personal factors have a significant effect on the child's reading performance. According to Yin et al.'s (2021) study, executive function is closely related to reading ability development in children. Olson et al. (2014) argued that the impact of genetic factors on child reading ability persists throughout all grades. However, the existence of innate factors like these does not mean the environmental factors are less impactful in child reaching ability development.

Home-related factors like family socioeconomic status, parental attitudes towards reading, and the home reading environment have proved to be of vital importance to child reading acquisition (Li & Dong, 2004; Mwoma, 2017; Yin et al., 2021). The size of home book collection is a strong predictor of the child's reading ability (Park, 2008); nevertheless, a large collection of books at home does not necessarily result in reading proficiency of the child. Ultimately, it is the child's reading ability that determines their reading volumes (van Bergen et al., 2018). In addition, amid the advancement of digital technologies, digital reading is getting increasingly prevalent in young children, which provokes the parents' concerns about the potentially negative impact of digital media on child reading ability development. Yet, Jiang et al.'s experimental study finds that there is no significant difference in the effects on child reading proficiency between print books and electronic books. As digital natives, the younger generation may develop the habit of digital reading, but this will not impose adverse impacts on their reading competence development.

The school reading environment can also make significance difference to the child's reading ability. Providing children with abundant reading materials and creating a reading-valued climate can help foster their love of reading. These moves, however, may not be sufficiently effective in light of the children's young age; the teacher's intervention in student reading behavior is often more critical (Li & Dong, 2004). As per Mwoma (2017), the teacher-student relationship and the teacher's reading instruction techniques are key to student reading ability development. More importantly, school-based reading education should not be confined to the established language education curriculum or be examination-focused (Zhong, 2019). This warrants high reading instruction proficiency of the language teachers.

A Practical Exploration of Teacher Training for Child Reading Education in China: A Case Study of Qinjinmuyu's "Reading Teacher Professional Competence Certification" Program in this issue is a study of how to construct a reading teacher professional competence training paradigm using Qinjinmuyu's (a private reading education and research institution) training program as an example. The program integrates reading instruction knowledge training, practical training, and assessment in a bid to enhance the reading teachers' professional standards (Yuan & Xu, 2024). Despite the lack of a quantitative validation of the program's outcomes (e.g., a large-scale experimental study or statistical analysis) in the study, the results of the post-training questionnaire and interviews with participants suggest that the program is effective in elevating the teachers' reading instruction competence.

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***Conflict of Interests**: None*

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COMMENTARY

Developing Effective Scales for the Improvement of Preschool Education Assessment in the New Era

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"A child miseducated is a child lost."
-John F. Kennedy

EDUCATION, a human activity aimed at promoting all-round growth of the individuals, is an inherently complicated process. Education assessment, an essential component of the process, plays a crucial role in ensuring the healthy development of the educational system (Yang, 2007). Effective education assessment is based on objective descriptions of the characteristics and details of the educational activity in examination. The scales can serve as objective, accurate, and valid tools for this purpose (Luo et al., 2009). As a means of quantitative evaluation, a scale can systematically gather, organize, and analyze relevant data on a specific educational activity using a set of established metrics, for the purposes of providing educators with intuitive information on student learning outcomes, teaching efficacy, curricular effectiveness, and the legitimacy of educational resource distribution. Such a data-informed assessment instrument can facilitate decision-makers identifying strengthens and weaknesses in current educational practices as well as making evidence-based adjustments of educational policies (Yan, 2003).

Among the many valuable assessment scales in the field of education, the Programme for International Student Assessment (PISA) is an exemplary one. It was developed under the auspices of the Organization of Economic Cooperation and Development (OECD) to test the skills and knowledge of 15-year-old students in mathematics, reading, and science. Additional frameworks like the financial literacy framework, creative thinking framework, and readiness for life-long learning framework were included in PISA in recent years (OECD, 2023). PICA not only measures the students' literacy in basic subjects but also evaluates their practical application and problem-solving abilities, providing wide perspectives on educational quality and student development for teachers, education policy makers, and other stakeholders.

Preschool education is critical to the physical, cognitive, social, and emotional development of the child. Scales for assessing preschool education practices can assist pre-primary teachers in developing better understanding of the growth needs of young children while also offering support for preschool education policy formulation. Currently, certain high-quality assessment tools are in widespread use in early childhood education, such as the Woodcock-Johnson, Third Edition Cognitive (WJ-III Cognitive) (Dombrowski, 2013), the social competence and behavior evaluation scale (SCBE-30) (LaFreniere & Dumas, 1996), and the early childhood environment rating scale-revised (ECERS-R) (Perlman et al., 2004). Nevertheless, ongoing social development has brought about changes in the growth environment and educational needs of the current generation of young children. Reform endeavors to enhance the quality of preschool education are underway in many countries (Yang & Li, 2016). As a result, there is a need to develop more advanced scales to cater for the development of preschool education in the new era. The development of fresh scales with high reliability and validity for pre-primary schooling has become a vital research subject in the field of preschool education research.

Descriptive Content Analysis of Scale Development Studies in Preschool Education between 2018-2023 Years in Turkey in this issue is a review of prior 63 studies of scale development or adaptation by Turkish pre-primary practitioners and researchers using the method of content analysis. It looks into the publication information, research designs, themes of the scale, sample sizes, and analysis methods of the studies selected. The article emphasizes the significance of the scales for preschool education and pinpoints core considerations in developing these scales (İnce Sezer & Yaşar, 2024). Despite its focus on the results of Turkish education researchers, the study can provide implications for the development of assessment scales for preschool education for their counterparts in other countries as well.

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ORIGINAL ARTICLE

Development of a Two-Tier Diagnostic Test to Assess Misconceptions about Biology Concepts at Primary School

Güntay Tasci

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***Abstract**: Developing tools to identify students' misconceptions about basic biology concepts is necessary. Therefore, a two-tier diagnostic test was developed to determine such misconceptions in primary school (3rd-4th Grade) students. The test content includes two-tiered multiple-choice questions addressing common misconceptions found in the literature on biology subjects in science education at the primary school level. The test's validation and reliability pieces of evidence are described through quantitative and qualitative data analysis of data obtained via the survey method. Data was collected from two samples in two stages, including 74 and 363 primary school students, respectively. The first stage has collected qualitative data by two-tier true-false items based on these common misconceptions. This data was analyzed per qualitative content analysis. Based on these findings, two-tier multiple-choice items were developed, and a two-tier diagnostic test was formed. In the second stage, data obtained was used to quantitative analyze the construct validity, internal consistency, and item parameters of the test. The study's results provided evidence of the validity and reliability of the primary school biology misconceptions diagnostic test (PBMDT), which consists of eight two-tier multiple-choice items.*

Science Insights Education Frontiers 2024; 25(2):4099-4122
DOI: 10.15354/sief.24.or652

How to Cite: Tasci, G. (2024). Development of a two-tier diagnostic test to assess misconceptions about biology concepts at primary school. Science Insights Education Frontiers, 25(2):4099-4122.

***Keywords**: Biology Education, Primary School Student, Diagnostic Test, Misconceptions*

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Conflict of Interests: *None*

Funding: *No funding sources declared.*

AI Declaration: *The author affirms that artificial intelligence did not contribute to the process of preparing the work.*

Introduction

THE CONSTRUCTIVIST approach provides a theoretical framework focusing on prior knowledge, experience, and meaning-making in learning (Fox, 2001). This approach has significantly impacted teaching processes, including field education. As a result, the idea that learners build their concepts related to natural phenomena has become more assertive, particularly in science education (Driver, 1989). Accordingly, Mintzes et al. (2001) reported that meaningful learning occurs when knowledge is structured with appropriately associated concepts to understand natural phenomena. However, in this process, students can also form thoughts unrelated to the scientific meaning of the concepts, resulting in misconceptions (Fisher & Moody, 2002). Although there are different names for misconceptions in the literature, such as preconceptions, naive conceptions, or alternative conceptions, the literature commonly highlights that they occur when learners construct natural phenomena differently from expert opinions or scientific understanding (Coley & Tanner, 2015; Fisher, 1985; Munson, 1994). Various studies tried to identify the sources of misconceptions (Coley & Tanner, 2015, 2012; Hershey, 2004; Yip, 1998). Sadler et al. (2013) suggest that teachers' field knowledge is essential. Yip (1998) points out that teacher characteristic, students' misunderstandings and incomplete understanding of lessons, daily life experiences, and daily language use contribute to forming misconceptions. Hershey (2004) suggests five categories of sources of misconceptions, including "oversimplifications, overgeneralizations, obsolete concepts and terms, misidentifications, and flawed research." Similarly, Tan et al. (2008) emphasize that some rules used in field teaching may become overgeneralizations and lead to misconceptions. Another piece of literature on misconceptions is textbook review studies. Barrass (1984) highlights "misleading terms" in biology textbooks that may create misconceptions. Fisher (1985) highlights the difficulties in changing incorrect textbook information. Based on the literature on the sources of misconceptions, the formation of these misconceptions through course teaching and teaching practices is called "didactic-based misconceptions" (Güngör & Özgür, 2009; Özcan & Bakır, 2023). In addition, Coley & Tanner (2015, 2012) propose a "cognitive construals" framework, analyzing the source of misconceptions with a cognitive psychological approach, and argue that flawed thoughts emerge when learners informally make sense of the world and have identified three categories of thought structures: "teleological, essentialist, and anthropocentric." Researchers expressed this as an effort to create common origins that effectively form different misconceptions in biology. Sadler et al. (2013) reported that studies using qualitative and quantitative techniques to identify misconceptions. In similar studies, researchers have employed various data collection tools such as interviews, drawings, concept maps, concept inventories, and tier diagnostic tests (Gurel et al., 2015; Sesli & Kara, 2012; Tekkaya, 2002; Yip, 1998). Tier tests, one of the diagnostic tests, based on the framework proposed by Treagust (1988), are frequently used in biology education, as in other fields, to investigate misconceptions about different concepts. These tools have been developed with multiple-choice questions in two-tier (Chandrasegaran et al., 2007; Chu et al., 2009; Griffard & Wandersee, 2001; Tsui & Treagust, 2010) in three-tier (Arslan et al., 2012; Caleon & Subramaniam, 2012), and in four-tier (Özden & Yenice, 2017) formats. Every tier of test can have a different number of options. In scoring tier multiple-choice items, it is seen that 0-1 scoring is used for each tier and their combinations (Arslan et al., 2012; Gurel et al., 2015; Ozden & Yenice, 2017; Sesli & Kara, 2012). However, answering multiple-choice items with guessing can be a limitation, which can be reduced by using two-tier tests, although it is essential to consider the potential impact of "diagonal response" when designing these types of tests (Loh et al., 2014). Loh et al. (2014) described "diagonal response" as a situation in which the connections between test tiers affect student responses.

Several studies have identified various biology-related misconceptions in many sub-fields of biology, such as cell biology, ecology, evolution, physiology, biochemistry, and heredity. The participants of these studies were university students, high school students, and secondary school and primary school students (Andrews et al., 2012; Butler et al., 2015; Fisher, 1985; Fisher & Moody, 2002; Kalas et al., 2013; Krall et al., 2009; Meir et al., 2005; Ozay & Haydar, 2003; Öztap et al., 2003; Parker et al., 2012; Sesli & Kara, 2012; Storey, 1992; Tekkaya, 2002; Yip, 1998). In addition, several studies examine the common misconceptions of the textbooks (Gündüz et al., 2016; Storey, 1989, 1990, 1992; Yilmaz et al., 2017). Various studies carried out, especially in science education at the primary school level, reported that misconceptions exist around concepts such as the water cycle, photosynthesis, light and shadows, the concept of living and non-living things, plants, animals, roots, nutrition, and nutrients (Allen, 2014; Asoko, 2002; Dimec & Strgar, 2017; Karpudewan et al., 2017; Lin, 2004; Pine et al., 2001; Topsakal, 2009; Uyanık, 2019). The literature mentioned above emphasizes that educators should identify misconceptions, explain their origins, and eliminate them. The primary school introduces the students to basic terms and factual information, a foundation for scientific concepts. Although primary school science classes do not focus on conceptual knowledge, they are crucial in structuring scientific concepts by providing essential factual information and terms. Misconceptions can significantly hinder scientific understanding, and it is essential to identify and address them early on. Based on this, the study aimed to develop a diagnostic test to determine students' misconceptions regarding biology concepts included in the primary school curriculum. Considering the various terms in the literature expressing misconceptions, it has become challenging to name misconceptions. However, in literature, it is recommended that educators avoid limiting students' understanding of natural concepts and instead approach their views on concepts flexibly (Maskiewicz & Lineback, 2013; Leonard et al., 2014). Accordingly, the study aimed to identify thoughts that tend to be misconceptions incompatible with scientific understanding in primary school students for different reasons. The current study uses misconceptions for false beliefs, naive concepts, conceptual confusion, alternative concepts, and incorrect conceptualizations that arise in students.

Method

Study Groups

The study involved third- and fourth-grade students from primary school and fifth-grade students from middle school. The students selected per convenience sampling participated voluntarily in the research. The first study sample consists of a total of 74 students. Of these students, 52.7 % (f = 39) are male and 47.3 % (f = 35) are female. The students consist of third-grade (f = 4), fourth-grade (f = 47), and fifth-grade (f = 23) primary school students. The second stage included 362 fourth-grade primary school students, 43.8 % (f = 159) boys and 56.2 % (f = 204) girls.

Development of Data Collection Tools

The stages suggested by Treagust (1988) for developing diagnostic tests were applied in developing the diagnostic test. The primary stages of this process include determining the content, identifying students' misconceptions, and developing the diagnostic test. In this study, the process involved reviewing relevant literature to identify common misconceptions, examining these misconceptions in the first study group, and based on this, developing a two-tier test, which applied to the second study group. The conceptual framework of the test contains the concepts reached by analyzing biology topics in the science curriculum and science textbooks for third and fourth graders. The literature reports common misconceptions about nutrition, foods, living things, the environment, and sensory organs across different education levels (Allen, 2014; Asoko, 2002; Dimec & Strgar, 2017; Karpudewan et al., 2017; Lin, 2004; Pine et al., 2001; Topsakal, 2009; Uyanık, 2019). So, the data collection tool for the first phase included thirty-two-tier true-false items forming from propositions to measure misconceptions first. These true-false items formed in the second tier by the statement "because…," asking students to explain their answers.

Table 1. Distribution of Identified Misconceptions* Across Questions and Tiers.

	First Tier			Second Tier
Misconceptions	Question No	I	II	Options
Sunlight is necessary for germination.	1		+	A
The seed is a non-living thing.	1	+		D E
Soil is a living thing.	1	+		B A
Nutrition and sleep produce our energy. [a]	2		+	A B C E
Foods consist of a single nutritional ingredient.	3	+		A B C E
Foods consist of a single nutritional ingredient.	4			E
Carbohydrates provide immunity.	4	+		C
Proteins do not provide energy.	4	+		B
Only carbohydrates provide energy.	4			A
Vitamins protect our bodies from diseases. [b]	4			D
A balanced diet is getting nutrients rich in protein. [c]	5	+		A B C E
Plants receive food from the soil. [d]	6	+		E
The plant gets energy for life from soil, water, and the sun. [i]	6			B
The flowers are related to growth. [e]	6			C
Sunlight is necessary for germination.	6			D
If a plant has no visible flowers, it is a flowerless plant [f]	7			D
All plants have flowers. [g]	7	+		
The flowers are related to growth.	7			B
If a plant has no flowers visible, it is a flowerless plant.	7			A C
The sensory organ is a source of stimulation.	8			E
Between sensory organs and the brain, there is no connection.	8		+	A B
A sensory organ perceives all things. [h]	8			C
Natural resources are unlimited.	9			A
Recycling produces natural resources.	9	+		B C
Recycling is the matter cycle.	9			E
Humans can create a natural environment.	10	+		A B C D
The life cycle is not associated with reproduction.	11			D
The life cycle is the life process.	11			C
The life cycle occurs in some animals	11		+	B
The life cycle occurs in plants	11			A

+, A, B, C, D, E: It has the expression containing the relevant misconception.
**: Explanations regarding the identified misconceptions were made based on the first study's findings.*
a: They state that our energy is produced by eating and digesting food. This situation points to students' confusion about the concept of nutrition-respiration.
b: Students state that protection from diseases is the duty of vitamins, and growth is the duty of protein.
c: Students consider consuming only or large amounts of protein necessary for a balanced diet.
d: Since they do not know the difference between organic and inorganic matter, they state that the soil nourishes the plant.
e: They state that all plants have flowers and that if they do not have flowers, they cannot grow. This situation points to students' Growth-Reproduction Concept Confusion.
f: Misunderstanding of terms due to lack of knowledge regarding the classification of plants.
g: The students call plants with distinct flowers, such as daisies and roses, "flowers," and these express the confusion between plant and flower concepts.
h: Inability to understand the limitations of sensory organs.
i: Misunderstanding of "life energy" due to lack of knowledge of cellular respiration and photosynthesis.

By analyzing these items (see Data analysis), participant statements regarding literature-based misconceptions were revealed, and created a list of misconceptions (**Table 1**). The two-tier items developed include these misconceptions under appropriate item roots. The first tier of these items contains two options. In the second tier, there are five options, one correct and four distractors (misconceptions), to explain the reason for the option marked in the first tier. This way, a draft diagnostic test of 11 two-tier multiple-choice items was reached. **Table 1** shows the distribution of the misconceptions measured according to the draft items.

Some items address the same misconception for all options, while others contain different misconceptions regarding the same situation. The study examined draft items for "diagonal response," which revealed that some choices were related to one or both options in the first tier. Some options incorporated student concepts that could be used in both selections in the first tier. However, it identified that some items of the second tier's options are related to one of the first tier's options. Therefore, to strengthen the connection between both options and the items in the second tier, some terms in options were removed for specific items (items 1, 4, 9, and 10). However, this was partially achieved in items 2, 3, 5, 6, 7 and 8. Thus, all second-tier items were used with five options to minimize guessing or chance.

Data Collection

The first data collection stage involved administering a 40-minute session of two-tier true-false type 30 items. In the second study, the diagnostic test, consisting of 11 items and Two-tier multiple-choice items, was administered in a 40-minute session. Both scales include an introductory text at the beginning that introduces the test to the participants. In the second stage, in the two-tier multiple-choice diagnostic test, participants were informed to mark the options they were sure were correct in both tiers. The students' classroom teachers carried out the data collection process.

Data Analysis

Qualitative Analysis Process

Textual data obtained in the study's first phase was subjected to content analysis. The incorrect statements in the first batch of answers were initially identified and analyzed for misconceptions. These misconceptions were then compared to the literature for supporting evidence. The situations were then coded based on the expressions used by the students, using *in vivo* coding. The coding process was conducted similarly to the example given. The explanations given by three participants who marked the "True" option for the statement "Soil is alive" have been presented.

> *"Because if it were not alive, trees and plants would not be able to produce vitamins and minerals" (Participant 35, Male, 4th Grade).*
> *"Because it grows flowers, trees, and grass in it." (Participant 52, Male, 4th Grade).*
> *"Because then the grass would not grow and the trees would not grow." (Participant 52, Male, 4th Grade).*

These statements indicate that the participants "true" answered that "soil is alive" because they believed that the soil produces food and sustains other living things. From this, it can be concluded that these students perceive the ecological relationships of the soil as an abiotic component with other living things as the "vitality of the soil." This article has identified the participants' misconceptions about living - and non-living things, and a part of these coded" soil is a living thing" as a code. As another example, the explanations of some participants who chose the wrong option for the statement "A seed is a living thing" are as follows.

> *"Because soil is lifeless unless it comes into contact with water and sunlight." (Participant 1, Female, 4th Grade).*
> *"Because it became not plant." (Participant 6, Male, 4th Grade).*
> *"Because they do not do things like nutrition, respiration, movement, and reaction." (Participant 15, Female, 4th Grade).*
> *"Because it is inanimate, but it comes to life when combined with soil, water and sun." (Participant 52, Male, 4th Grade).*
> *"Because it can grow and become alive after you plant it." (Participant 60, Male, 4th Grade).*

These statements supported the participants' belief that the seed is alive when it turns into a plant. Another explanation for this misconception emphasizes the necessity of soil, water and sun for germination. At the same time, the idea that the seed is non-living has emerged based on the idea that the seed cannot perform some life events such as nutrition and respiration. These situations revealed that these students perceived the dormant seed as an "inanimate thing." In this article, this misconception is coded as "A seed is a non-living thing." The process was carried out for all items, and **Table 1** presents the identified misconceptions from the student statements and their corresponding codes.

Table 2. Two-Tier Multiple-Choice Item Scoring Example.

		Scoring		
Item	Misconception	First Tier	Second Tier	Both Tiers
Living being… I. is soil.	Soil is a living thing.	0		
Because: A. It feeds on water and the sun.	Soil is a living thing.		0	0
B. Creatures such as plants and worms live on the soil.	Soil is a living thing.		0	0
C. The seed is dormant*.	+		1	0
D. The seed becomes alive after germination.	The seed is a non-living thing.		0	0
E. When the seed turns into a plant, it becomes alive.	The seed is a non-living thing.		0	0
Other:				
II. is the seed.	+	1		
Because: A. It feeds on water and the sun.	Sunlight is necessary for germination.		0	0
B. Creatures such as plants and worms live on the soil.	The seed is a non-living thing.		0	0
C. The seed is dormant*.	Proper conceptualization		1	1
D. The seed becomes alive after germination.	The seed is a non-living thing.		0	0
E. When the seed turns into a plant, it becomes alive.	The seed is a non-living thing.		0	0
Other:				

**: In the original version, "sleep statement" was used instead of the term "dormant."*

Table 3. Creating Item Scores.

Levels	First Tier	Second Tier	Both Tiers
Scientific conceptualization	1	1	1
Partial information	0	1	0
Partial information	1	0	0
Lack of knowledge	0	0	0

1: True, 0: False

Scoring Rule for Two-Tier Testing

The response combinations to the two-tiered multiple-choice items were considered separate and combined propositions. **Table 2** displays two sets of options - one correct and one incorrect - for the first tier of the items developed for the diagnostic test.

Table 3 presents a summary of the scoring rules. The first and second tiers give a point for selecting the correct option, while selecting the wrong option results in zero points.

Additionally, combining both tiers creates twelve different answer combinations for each question with the "other" option. If both tiers are correct, a cognitive state suited for scientific conceptualization is achieved. For instance, in the example provided in the table, "Living being II is the seed. Because: C. The seed is in a dormant state." This combination of responses represents the "scientific (proper) conceptualization" level. Apart from this, there are two different combinations. One is to mark the correct option on one tier and the wrong option on the other and mismark both tiers. Correct answer combinations in one tier and incorrect answers in the other were considered a "partial information" situation. Incorrect marking of both tiers was considered the "lack of knowledge" level.

Validity and Reliability

Quantitative and qualitative analyses were used to assess the psychometric properties of the PBMDT. Experts provided feedback on codes created during data coding for the test's item development phase. This feedback helped ensure that the test accurately covered the misconceptions and content presented in **Table 1**.

Construct validity, reliability, and item parameters of the diagnostic test were assessed using test scores from a large sample group. The study aimed to establish validity and reliability evidence for the first, second, and both tiers of diagnostic test scores using the framework proposed by Adams and Wieman (2011). Construct validity was determined using factor analysis, which involved exploratory factor analysis, minimum residual estimation method, and Promax, one of the oblique rotation techniques. And eigenvalue and parallel analysis graphs were used to determine the dimensions (Adams & Wieman, 2011; Floyd & Widaman, 1995; Ramlo, 2008). The JASP program was utilized to conduct all analyses.

Reliability analysis was conducted after assessing the unidimensionality of the diagnostic test in terms of its measured structure. This process involved calculating several criteria such as McDonald's ω, Cronbach's α, Guttman's λ_6, KR-20 internal consistency, and the Greatest Lower Bound index, all with a 95 % confidence interval. Additionally, the test's psychometric properties were evaluated by examining the item difficulty index, item discrimination indices, and Point Biserial Correlation values. Criteria recommended by Fisseni (1997; cited in Bühner 2006, p. 140), George and Mallery (2022), and Haladyna and Rodriguez (2013) were taken into account during this process. Lastly, the qualitative findings of the test were quantified using frequency and rate (%) based on the general total.

Findings

Findings Regarding Psychometric Properties

Results Regarding Construct Validity

The Kaiser-Meyer-Olkin test and Bartlett's test results were first examined among the factor analysis results of the diagnostic test. The KMO values obtained with the KMO test for the data set at this stage (KMO = 0.727 for the first tier; KMO = 0.779 for the second tier; KMO = 0.784 for both tiers) are close to the desired value of 0.80. Bartlett's test results were statistically significant (Chi-square (55) = 921.985 for the first tier; Chi-square (55) = 1227.522 for the second tier; Chi-square (55) = 1568.360 for both tiers). Accordingly, the data set was suitable for factor analysis regarding sample size and correlation. According to the rotated analysis results, the first tier showed a single-factor structure, but the second and both tiers showed a two-dimensional structure. When the factor loadings for the rotated analysis were examined, it was seen that the sixth (0.364), second (0.334), and eleventh (0.23) questions in the first tier did not have the desired factor loadings. In the two-factor structure formed in the other tiers, compatible dimensions that can be considered in line with theoretical expectations regarding subject areas, concepts, or misconceptions did not form. In this context, DY6 (0.364), DY2 (0.334), and DY11 (0.231), because their factor loadings were below 0.40, were removed from the analysis, and the analyses were repeated. It was observed that the KMO values obtained by the KMO test for the data set at this stage (KMO = 0.822 for the first tier; KMO = 0.810 for the second tier; KMO = 0.824 for both tiers) provided the desired value of 0.80 recalculated Bartlett's test results were found to be statistically significant (Chi-square (28) = 653.021 for the first tier; Chi-square (28) = 801.279 for the second tier; Chi-square (28) = 892.179 for both tiers). **Table 4** shows the factor loadings and factor characteristics calculated at this stage. Table 4 shows a one-dimensional structure for all tiers with the eight items in the analysis. Factor loadings of the items vary between the lowest 0.495 and 0.801.

It is seen that the eigenvalues for each tier are higher than one, and the highest is (3.031) for both tiers. It can be seen that the variances explained by the tiers are above 0.30, and both tiers explain the highest variance (0.379).

Reliability and Item Analysis Findings

Reliability indices were calculated for eight diagnostic test items based on each tier's data. **Table 5** presents the results.

Table 4. Factor loadings and Rotated Solution Factor Characteristics.

First Tier		Second Tier		Both Tiers	
items	Factor 1	items	Factor 1	items	Factor 1
DY5	0.698	CS3	0.801	T3	0.755
DY8	0.606	CS7	0.664	T7	0.747
DY7	0.572	CS10	0.599	T10	0.613
DY9	0.548	CS5	0.569	T5	0.609
DY3	0.535	CS9	0.533	T9	0.588
DY1	0.529	CS4	0.521	T4	0.528
DY4	0.517	CS8	0.502	T1	0.525
DY10	0.513	CS1	0.495	T8	0.507
Sum Sq. Loadings	2,579		2,817		3,031
Proportion var.	0.322		0.352		0.379

Table 5. Statistics on Diagnostic Test.

Estimate	First Tier			Second Tier			Both Tiers		
	Point estimate	95 % CI		Point estimate	95 % CI		Point estimate	95 % CI	
		LL	UL		LL	UL		LL	UL
McDonald's ω	0.658	0.605	0.711	0.658	0.605	0.711	0.677	0.627	0.728
Cronbach's α	0.658	0.601	0.708	0.666	0.611	0.715	0.686	0.634	0.732
Guttman's λ6	0.637	0.576	0.697	0.647	0.589	0.706	0.668	0.606	0.729
Greatest Lower Bound	0.716	0.679	0.780	0.723	0.686	0.786	0.744	0.703	0.806
Average interitem correlation	0.194	0.153	0.234	0.199	0.157	0.241	0.215	0.168	0.260
means	4.601	4.391	4.811	2.865	2.661	3.069	2.664	2.459	2.868

The first tier has the highest test mean (4.601) but is the lowest for both tiers (2.664). The average correlation value between the items is 0.215 for both tiers. Three reliability estimate methods based on internal consistency yielded values in the 0.60-0.70 range. However, reliability estimates above 0.70 occur in the upper band within confidence intervals. The test showed internal consistency at a rate higher than 0.70 in all three data sets. In addition, the KR20 reliability index calculated for both tiers scores as 0.661. Item difficulty indices for the first tier varied from 0.366 to 0.738, with an average of 0.575, indicating medium difficulty (0.20-0.80; Bühner, 2006). Difficulty indices for the second tier ranged from 0.176 to 0.603, with an average of 0.358. The difficulty level increased to 0.20 for the

Table 6. Item and Options Analysis Findings.

Q	FT	ST A %	B %	C%	D%	E%	Other%	Total%	Empty%	DI	ID	PBC	sd.
1	I	10.8	8.9	0.3	1.4	1.7	0.3	23.3		0.320	0.438	0.53	0.497
	II	6.1	0.6	17.7	24.9	24.4	0.6	74.2	2.5				
3	I	28.9	22.6	8.0	1.7	0.8	0.6	62.5		0.439	0.174	0.58	0.379
	II	6.1	7.7	5.0	13.5	1.1	1.1	34.4	3.0				
4	I	9.6	6.2	5.1	2.3	0.8	0.8	23.9		0.343	0.333	0.54	0.472
	II	6.8	9.6	33.5	16.1	4.8	1.7	72.7	3.4				
5	I	9.2	2.9	2.3	3.4	-	6.3	24.1		0.398	0.567	0.60	0.496
	II	4.0	6.0	1.4	58.2	2,3	0.9	72.8	2.9				
7	I	2.6	6.1	1.4	9.6	4.3	0.3	24.3		0.450	0.198	0.59	0.399
	II	26.4	1.4	21.2	4.3	18.0	1.4	72.8	2.9				
8	I	4.0	1.2	2.6	53.9	1.2	1.2	64.0		0.321	0.521	0.54	0.500
	II	16.1	4.6	6.6	2.0	3.2	0.3	32.9	3.2				
9	I	5.7	12.2	21.2	2.8	17.3	0.6	59.8		0.350	0.229	0.48	0.421
	II	1.4	3.1	9.3	13.9	7.6	1.7	37.1	3.1				
10	I	30.4	3.9	3.9	18.3	1.1	0.8	58.6		0.364	0.204	0.53	0.403
	II	5.4	7.0	2.0	5.1	17.5	1.4	38.3	3.1				
mean										0.579	0.330	0.548	

Q: Question; FT: First Tier; ST: Second Tier; DI: Discrimination Index; ID: Item Difficulty; PBC: Point Biserial Correlation;

second tier. Similar values occurred in both tiers, and the average difficulty changed to 0.333. The difficulty indices of items 3, 7, 9, and 10 in these tiers are high (< 0.229). Accordingly, although these levels are still at the average difficulty level, it can be seen that the difficulty level has increased; that is, they have approached the value of 0.20. Table 6 gives the option analysis results from these results according to the ticking percentages of the options for the items and the item parameters calculated for both tiers.

It is seen that the distractors worked for the correct answer in the first tier for items 1, 4, 5, 7, and 8. The rate of correct answer combinations in these items seems to follow the item difficulty indices. The correct answer combination for the 5th item is 58.2 %, the item difficulty index is 0.567, the correct answer combination for the 8th item is 53.9 %, and the item difficulty index is 0.521, indicating that the items are of average difficulty. The findings showed that items 3, 9, and 10 had lower rates of correct answer combinations (13.5 %, 13.9 %, and 17.5 %, respectively). Also, certain option combinations led to strong distractors: item 3 (I - A, 28.9 %), item 9 (I - C, 21.2 %), and item 10 (I - A, 30.4 %). These items appear difficult and discriminative based on their discrimination (0.439; 0.350; 0.364) and item difficulty indices (0.174; 0.229; 0.204). Upon examining the scoring patterns of the multiple-choice items within the second tier of the test

Table 7. Comprehension Distribution by Item and Subject Areas.

		Scientific Conceptualization		Lack of Knowledge		Partial Information		Total	
Q	Concept	f	%	f	%	f	%	f	%
1	Plant	82	2.82	92	3.17	189	6.51	363	12.50
3	Foods ingredients	58	2.00	232	7.99	73	2.51	363	12.50
4	Functions of foods	121	4.17	86	2.96	156	5.38	363	12.50
5	Balanced diet	206	7.09	92	3.17	65	2.24	363	12.50
7	Plant	72	2.48	95	3.27	196	6.75	363	12.50
8	Sensory organs	190	6.54	133	4.58	40	1.38	363	12.50
9	Natural Resource	79	2.72	220	7.58	64	2.20	363	12.50
10	Natural and Artificial Environment	67	2.31	222	7.64	74	2.55	363	12.50
	Total	875	30,13	1172	40.36	857	29.51	2904	100

Q: Question;

items, it has been determined that the distractor options included with each item are marked at a rate that varies between 1.9 % and 9.5 %. This finding suggests that these specific options have been chosen less frequently than other options. Furthermore, **Table 6** highlights an additional finding regarding the blanking rates, which indicate that these rates fall below 3.4 %. The response rates regarding the “Other” option offered in the items range between 0.3 % and 1.7 %.

Findings Regarding Comprehension Status

Table 7 presents the distribution of participants’ responses by subject area in the PBMDT.

According to the table, participants responded to the fifth item about balanced nutrition (f = 206; 7.09 %), the eighth item about sensory organs (f = 190; 6.54 %), and the fourth item about the functions of foods (f = 121; 4, 17 %) are items with a high level of scientific conceptualization. Scientific conceptualization rates for other substances vary between 2 % and 2.82 %. When examined in terms of all participants, the level of scientific conceptualization is 30.13 %, while the level of partial knowledge and lack of knowledge is approximately 70 %.

Table 8 presents the distribution of misconceptions regarding subject areas.

Based on the table, the participants have higher rates of misconceptions regarding nutritional content than others. Specifically, they have the following misconceptions: “Foods consist of a single nutritional ingredient.” (f = 325, 12 %), “Proteins do not provide energy” (f = 97, 3 %), and “A balanced diet is getting nutrients rich in protein.” (f = 139, 5 %).

Table 8. Distribution of Misconceptions Determined by the PBMDT.

		SC		LoK		PI		Total	
Subject area	Misconceptions	f	%	f	%	f	%	f	%
Foods Ingredients	Foods consist of a single nutritional ingredient.			235	8.4	90	3.2	325	12
	Proper Conceptualization	58	2.1					58	2
Functions of Food Ingredients	Proper Conceptualization	121	4.3					121	4
	Proteins do not provide energy.			60	2.1	37	1.3	97	3
	Vitamins protect our bodies from diseases.			11		57	2.0	68	2
	Only carbohydrates provide energy.					24	0.9	24	1
	Carbohydrates provide immunity.					18	0.6	18	1
Balanced Diet	Proper Conceptualization	206	7.4					206	7
	A balanced diet is getting nutrients rich in protein.			77	2.8	62	2.2	139	5
Plant	If a plant has no flowers visible, it is a flowerless plant.			52	1.9	189	6.8	241	9
	The seed is a non-living thing.			10	0.4	178	6	188	7
	Proper Conceptualization	154	5.5					154	6
	Soil is a living thing.			79	2.8	4	0.1	83	3
	The flowers are related to growth.			21	0.8	5	0.2	26	1
	Sunlight is necessary for germination.					5	0.2	5	0.2
Natural resource	Recycling produces natural resources.			126	4.5	32	1	158	6
	Recycling is the matter cycle.			62	2.2	26	1	88	3
	Proper Conceptualization	79	2.8					79	3
	Natural resources are unlimited.			20	0.7	5	0.2	25	1
Natural and Artificial Environment	Humans can create a natural environment			215	7.7	72	3	287	10
	Proper Conceptualization	67	2.4					67	2
Sensory Organs	Proper Conceptualization	190	6.8					190	7
	Between sensory organs and the brain, there is no connection.			76	2.7	22	1	98	4
	A sensory organ perceives all things.			25	0.9	9	0.3	34	1
	The sensory organ is a source of stimulation.			12	0.4	4	0.1	16	1
	Total	875	31	1081	39	839	30	2795	100

SC: Scientific Conceptualization; LoK: Lack of Knowledge; PI: Partial Information;

Regarding the misconception that foods consist of a single nutritional content, the participants presented as reasons “oranges consist of vitamin C” (28.9 %), and “oranges are a source of vitamins” (22.6 %) (**Table 6**, Item 3). However, regarding the functions of nutritional contents, students give the option that proteins do not provide energy, as well as the reasons that protein is only related to growth and development and carbohydrates are only related to providing energy. Many misconceptions were identified in the two questions numbered one and seven within the subject area of vitality, especially regarding the concept of plants. Plant and flower conceptual confusion was coded 241 times at a rate of 9 % at the levels of partial knowledge and lack of knowledge. In this question, the reasons given by the learners that some plants consist of only leaves and branches were marked 26 % in option A and 21.2 % in option C. However, between 0.2 % and 7 % of misconceptions arise regarding seeds, germination, reproduction - growth, and plant physiology. The misconception that "the seed is non-living" (f = 188, 7 %) was mainly explained by the distractor that "the seed becomes alive when it turns into a plant." The participants explained that "seeds and soil are alive" by nourishing them with water and sun. This misconception means defining vitality for the soil option. In terms of seeds, it shows that students have developed the wrong idea that sunlight is necessary for germination. Regarding natural resources, some students believe that recycling produces these resources. For example, they think that natural resources are regenerated when paper is recycled (21.2 %) and that recycling is the cycle of natural resources (17.3 %). Regarding the natural and artificial environment, some students believe that humans can create a natural environment by building parks and gardens (30.4 %). Finally, some students fail to understand that the sense organs are connected to the brain (4 %).

Discussion

PBMDT Psychometric Properties

The study evaluated the PBMDT's validity and reliability using qualitative and quantitative methods. As per Tregaust's (1988) diagnostic test development stages, the first step is to define misconceptions mentioned in the literature (Allen, 2014; Asoko, 2002; Dimec & Strgar, 2017; Fisher & Moody, 2002; Krall et al., 2009; Karpudewan et al., 2017; Topsakal, 2009; Uyanık, 2019). After testing these misconceptions in the first group's participants, the findings were used to draft items for the PBMDT. The following two steps ensured the face validity of the PBMDT. Firstly, we created the questions based on the guidelines for writing multiple-choice questions by Haladyna and Rodriguez (2013). Secondly, we had a field expert and a teacher examine the questions. Thus, the suitability of the items in terms of the understandability of their contents was examined through interviews. However, within the scope of the options analysis, the low blanking rate was considered a positive finding regarding the clarity and level of suitability. The low rate of use of the "other" option indicates the adequacy of the distractor pool in the second tier for this sample. In the development of diagnostic tests, applications for the readability of the tests have been included (Arslan et al., 2012). In this study, relatedly, primary school teachers consulted their opinions. However, the items were examined regarding the "diagonal response" situation suggested by Loh et al. (2014). In this context, while the risk of logical clues between tiers can be reduced in some items, this situation has been partially eliminated in some items.

The misconceptions presented in Table 1 were initially formed by the literature. These misconceptions were verified in the first sample of the study. In addition, the specification table, one of the recommended ways to ensure content validity (Adams & Wieman, 2011; Crocker & Algina, 1986), was prepared based on this finding. In similar studies in the literature where tier tests were developed, it is seen that the misconceptions claimed to be measured by the tier test were examined with tables of specifications and propositions (Arslan et al., 2012; Liampa et al., 2019; Lin, 2004; Odom & Barrow, 1995). Expert opinions were evaluated regarding misconceptions of the content presented in Table 1, draft items to measure them, and the targeted structure. These applications have provided qualitative evidence for the construct and content validity of PBMDT. Additionally, in the study, a quantitative data set was reached with the scoring rule following the literature (Chandrasegaran et al., 2007; Kilic & Saglam, 2009; Tan et al., 2002; Liampa et al., 2019; Sesli & Kara, 2012). With the data set created in this way, evidence regarding the construct validity of the PBMDT was obtained. Factor analysis is recommended to provide evidence regarding the construct validity of cognitive tests (Adams & Wieman, 2011; Ramlo, 2008). Although it is reported that there are different opinions regarding the size of factor loadings in the literature regarding the construct validity of cognitive tests, items with appropriate factor loadings (> 0.40) were selected (Floyd & Widaman, 1995; Kline, 2005). The PBMDT, which measures misconceptions regarding different biology subjects, showed a one-dimensional structure.

Attention is drawn to the measured structure model to find evidence regarding reliability, another desired criterion in measurement tools. Yurdugul (2005) emphasizes using different reliability indices according to internal consistency, depending on the characteristics of the measured structure. Reliability indices were calculated using four different methods for the PBMDT, which has items with different factor loadings. The KR20 reliability index, calculated as 0.661 according to the scores of both tiers of the PBMDT, was accepted as the reliability index of the scale. These indices are at acceptable levels within the lower and upper bands of the 95 % confidence intervals determined in the literature (George & Mallery, 2022). In addition, it can be said that the reliability indices obtained for the PBMDT are compatible with tier-test development studies. According to Fisseni (1997; cited in Bühner 2006, p. 140), the discrimination of the PBMDT's items is at appropriate levels (> 0.30) for all tiers. Based on the findings obtained in the study, options analysis was made based on marking frequencies. The literature indicates that the distractors marked less than 5 % are called "non-functioning distractors" (Gierl et al., 2017; Haladyna & Rodriguez, 2013). Tan et al. (2008) stated that the misconceptions that occurred at a 10 % higher rate were common misconceptions. Accordingly, an option with a rate lower than 10 % in the study may not be used in different studies. This study used a five-option structure to prevent "diagonal response." However, the finding that the misconceptions identified for the distractors are working distractors is a favorable situation for the test's psychometric properties. Based on these findings, it was concluded that the PBMDT has appropriate psychometric properties and appropriate validity and reliability evidence is provided.

Misconceptions Identified

The PBMDT showed that students, as misconceptions, believe that foods have only one kind of food ingredient and cannot understand the functions of nutrients and balanced nutrition. These misconceptions are similar to those reported by, who suggested that people believe that "we only eat to gain energy, fats are unhealthy, and only fats contain fat" (Allen (2014). The study confirms students' misconceptions that foods have only one nutritional component and that fats are unhealthy. Allen (2014) presented the misconception that proteins are used only to gain energy. In addition, the current study describes the misconception that protein is only adequate for growth and development. Accordingly, students have a misconception that essential food ingredients only serve one purpose. The idea that the food ingredients identified by the participants may have only one function can be seen as a result of the essentialist thinking in students suggested by Coley and Tanner (2012). The research shows that students often have misconceptions about seed, flower, germination, plant nutrition, and vitality concepts. Plant-related misconceptions were reported in several studies conducted at different education levels (Allen, 2014; Haslam & Treagust, 1987; Hershey, 2004; Krall et al., 2009; Wynn et al., 2017). For example, Allen (2014) reports the misconceptions regarding the concept of vitality, such as that "fire is alive" and "seed is a non-living thing." In this study, the misconceptions that "seed is inanimate" and "soil is alive" were determined. The misconception that the soil is alive, which emerged among the participants, is based on the misconception that the soil can be fed by water and sun and can create nutrients and other living things. This situation is compatible with attributing nutritional and reproductive characteristics to the soil within the scope of anthropocentric thought proposed by Coley and Tanner (2012). As for the seed, there is a misconception that it is alive when it turns into a plant. Allen (2014) explains these misconceptions, also identified by Topsakal (2009), with the basic common features of living things and proposes the concept of “dormancy” for scientific conceptualization. However, the students’ view that sunlight is necessary for germination and that the plant receives nutrients from the sun or the soil indicates inappropriate thoughts about plant physiology. Dimec & Strgar (2017) reported that several pieces of research on photosynthesis identified misconceptions such as “plants get their nutrients from their environment, especially from the soil; roots are nutritional organs; sunlight is food for plants; and confusion about respiration.” Krall et al. (2009) reported that sunlight is necessary for seed germination, and misconceptions that the plant obtains nutrients through its roots as non-scientific conceptualizations. Hershey (2004) stresses the impact of obsolete concepts and terms, oversimplification, and overgeneralization on the formation of misconceptions. Yip (1998) reported that one of the sources of learners’ misconceptions was the use of these terms in daily life and spoken language. For example, the fact that the term “flowers” is frequently used interchangeably with “plants” in everyday language makes it difficult to understand this concept in a biological context.

Conclusions

A comprehensive literature review is presented that identifies misconceptions and investigates their causes. The developed PBMDT has identified misconceptions that are in line with different opinions found in these literatures regarding the sources of such misconceptions. Similar misconceptions can be found in textbook reviews and among students at various education levels, including university students (Cakiroglu & Boone, 2002; Dimec & Strgar, 2017; Griffard & Wandersee, 2001; Haslam & Treagust, 1987; Krall et al., 2009; Lin, 2004; Yip, 1998). Misleading terms used in textbooks or didactic teachings may encourage learners to fill in the knowledge gaps with thoughts incompatible with scientific understanding. Depending on the age and education level of the learner, these concepts may be simplified and their scope reduced. However, it is essential to distinguish between the daily usage of language and scientific terminology in our lessons and use terms according to scientific understanding. Therefore, it is crucial to avoid oversimplifying and overgeneralizing the knowledge and terminology of the field of biology when educating students. It is also crucial to fill knowledge gaps with scientifically appropriate ideas and to support students in thinking about biology and natural phenomena. However, teachers must pay attention to not supporting ideas that may lead to misconceptions. Teachers’ determination of these tendencies in their students through PBMDT in their classroom evaluations will positively affect concept teaching in advanced education levels.

Ethics Statement

The participants were presented with an informed consent form before participating. The participants were informed that their participation in the test was entirely voluntary and that they could leave the study at any time. During the data collection, the data were anonymized, and no personal and corporate information was collected or used in the research. This study was conducted with the approval of Erzincan Binali Yıldırım University Human Research Ethics Committee (Protocol Number: 02/15).

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Received: June 05, 2024
Revised: July 04, 2024
Accepted: July 04, 2024

ORIGINAL ARTICLE

Descriptive Content Analysis of Scale Development Studies in Preschool Education between 2018-2023 Years in Turkey

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***Abstract**: The purpose of this research is to identify the situation through content analysis of scale development studies conducted by Turkish researchers in the field of preschool education. Thus, the overall trend of scale development research in preschool education was established. This research is a document analysis study. The documents studied are national and international articles published by Turkish preschool teachers. These articles were content-analyzed. Scale studies conducted between 2018 and 2023, which encompass preschool education, educators, parents, and preschool resources, were searched. In total, 63 article studies were included in this content analysis. For data collection, a data collection form was prepared for content analysis, inspired by the 'Publication Classification Form' which was used to conduct a detailed scanning process. According to findings of the research, the scale of development studies (63 %) conducted in pre-school education, largely in 2018, with two authors, was larger than that of adaptation studies. The majority of studies (49%) were published in the Turkish database TR ULAKBİM, with a focus on the social-emotional domain (16%) and science-education (67%). It was found that the descriptive method was preferred as the research method, that children were the majority of the sample (38%), that the sample size was chosen between 201 and 500, and that factor analysis and descriptive analysis were employed as analysis methods.*

Science Insights Education Frontiers 2024; 25(2):4123-4143
DOI: 10.15354/sief.24.or656

How to Cite: İnce Sezer, S., & Yaşar, M. D. (2024). Descriptive content analysis of scale development studies in preschool education between 2018-

İnce Sezer & Yaşar. (Turkey). Analysis of Scale Development Studies in Preschool Education.

2023 years in Turkey. Science Insights Education Frontiers, 25(2):4123-4143.

Keywords: Early Childhood Education, Scales, Scale Development, Holistic Development, Content Analysis, Science Education

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Conflict of Interests: None

Funding: No funding sources declared.

AI Declaration: The author affirms that artificial intelligence did not contribute to the process of preparing the work.

Introduction

DEVELOPMENT should be considered holistically, with each developmental domain holding a crucial place in a child's overall well-being. The preschool period is a stage that encompasses children from birth to the age of 6. The preschool period is highly significant for children to acquire a variety of skills in terms of physical, cognitive, social, emotional, and self- regulation aspects (Uluyurt, 2012). During this period, children lay the foundation for their personality development by transferring the skills and achievements they acquire to their adulthood. Preschool education takes on the responsibility of nurturing and enhancing a child's curiosity, thinking, and learning skills (Senemoğlu, 1994). The majority of an individual's personality and character development occurs during early childhood (Senemoğlu, 2004). Through preschool education, children lay the foundation for the formation of their own identity, become aware of their skills and responsibilities, and progress towards becoming happy individuals in the future (Acun and Erten, 1993). When looking at children's development, it appears to be multidimensional, including social-emotional, cognitive, physical, language, and self-regulation skills. The preschool period is a stage where a child's holistic development is rapid, and they are most receptive to the stimuli in their environment. The quality and adequacy of stimuli available to children are related to their exploration, learning levels, and learning speed (Ministry of National Education (MoNE) 2013). Preschool education programs have been shown to provide significant benefits for both children and their families in research studies (Organisation for Economic Co-operation and Development (OECD), 2010: 294). The primary aim of preschool education programs is to maximize children's holistic development, interactions, and positive behaviors. Preschool programs should include activities such as language, drama, science, art, play, music, language, socialization, emotional development, and more (Eurodice, 2010). The positive effects of preschool education continue throughout an individual's entire life (Barnett, 2008; Dickinson and Porche, 2011).

As the world changes and develops, individuals' needs also evolve. The theoretical hypotheses put forth in educational research studies should be substantiated through empirical investigations. The increasing diversity of research conducted to meet individuals' needs and provide education holds significant importance (Kayahan and Koca, 2004). Therefore, the development and adaptation of scales aimed at researching children's holistic development are crucial in assessing the levels of their development. The screening of developed or adapted scales that not only focus on a single developmental domain but encompass all areas of development in a descriptive study will prove to be efficient for early childhood researchers and facilitate their work in terms of accessibility.

To understand the quality and effectiveness of the education provided, it is essential to thoroughly examine the program, the competence of teachers in their respective fields, school staff, family, and the environment from various perspectives (Güçhan Özgül, 2011). It is imperative to design the environments for children's holistic development, growth, and learning based on the preschool period in the best and highest quality way possible (Koçyiğit, 2007). When examining research on teaching, the applicability of hypotheses in studies should be supported by experimental research. To ensure scientific and objective quality in research, appropriate statistical tests and scales are required. Scales are used to display the mathematical properties and symbols of measurement results in studies (Turgut and Baykul, 2012). The increasing number of studies necessitates the classification of research according to specific characteristics, enabling the formation of a particular perspective (Bartan and Şahin, 2017). It is crucial to prioritize scientific research with the aim of meticulously reviewing studies and examining them according to established criteria, in order to create high-quality education programs that are relevant to contemporary society and researchers (Tarman, Güven, and Aktaşlı, 2011). When analyzing the existing studies, it is observed that research on the preschool period is often limited to specific domains such as the field of science, art education, social-emotional development, or drama. Comprehensive content analyses encompassing the preschool period and addressing both scale development and adaptation are notably lacking in the literature. For example, Özpir and Mantaş (2018) conducted content analyses of articles related to preschool science education. The increasing interest in the preschool period in recent years has led to a growth in the number of scientific studies, primarily due to scale development and adaptation efforts. To establish a systematic perspective, researchers have been motivated to define specific criteria and compile studies conducted in light of these criteria. This will enable future researchers to have a clearer understanding of which scales have been developed in recent years and what needs exist. Through this work, researchers will have the opportunity to examine more recent studies more quickly. In summary, it can be said that content analyses play a crucial role in reaching scientific research more efficiently and with stronger evidence (Aydoğdu, 2015).

Purpose of the Study and Research Questions

In this section the purpose of the study and the research questions were presented. Studies related to the preschool period have been on the rise, and as a result, there has been a growing interest in the development and adaptation of scales encompassing the preschool period. The purpose of this research is to identify the situation through content analysis of scale development studies conducted by Turkish researchers in the field of preschool education. Thus, the overall trend of scale development research in preschool education was established. When examining scale studies covering the preschool period, it is evident that content analyses are primarily conducted in a unidirectional manner, focusing on specific domains such as preschool children, parents, preschool teachers, prospective preschool teachers, books related to the preschool period, and the like. Content analyses are mainly conducted separately for areas like art, social-emotional development, science, or mathematics. This study, however, aims to provide a content analysis of scale development and adaptation studies related to the preschool period and the entire preschool period itself, covering the scale studies conducted between 2018 and 2023. Turkish researchers' publications on preschool education in both national and international journals were examined in terms of the type of scale studies, the indexes in which they were indexed, the subject of the study, the methodology, data collection tools, sample size and sampling, and data analysis methods.

In this study, the following research questions were addressed:

1. What is the distribution of preschool scale development publications by years?
2. What is the number of authors in publications covering pre-school education in Turkey in the last 6 years?
3. In publications that encompass preschool education in Turkey, what are the frequently investigated topics in the last 6 years?
4. In publications encompassing the preschool period and education in Turkey, what are the frequently used research methods in the last 6 years?
5. In publications related to preschool education and the preschool period in Turkey, what are the frequently utilized sampling methods and sample sizes in the last 6 years?
6. In publications concerning preschool education and the preschool period in Turkey, what are the commonly adopted data analysis methods in the last 6 years?
7. In publications on preschool education and the preschool period in Turkey, what are the types and proportions of scale studies in the last 6 years?
8. In publications on preschool education and the preschool period in Turkey, what are the indexes and their proportions in which articles were indexed in the last 6 years?

Research Method

In this section the research method and its subsections; data collection process, data collection tools and data analysis process; for this study were presented. This research is a document analysis study. The documents studied are national and international articles published by Turkish preschool teachers. These articles were content-analyzed. Content analysis is a technique widely used in the social sciences. Content analyses are particularly beneficial in preventing the oversight of critical aspects in research, allowing for a more comprehensive examination (Neuman, 2017, p. 468). The scale development and adaptation studies that were taken into consideration and examined in this research comprise articles published in national and international journals in Turkey, as well as master's and doctoral theses. These studies were analyzed using content analysis. Content analysis is designed to generate unbiased, objective inferences from studies (Kondracki, Wellman, Fada, & Amundson, 2002). The primary purpose of content analysis is to systematically reduce the overwhelming abundance of information, making it more visible (Tavşancıl and Aslan, 2001, p. 48). In this study, content analysis was systematically conducted in accordance with the research questions.

Data Collection Process

In this content analysis study, when selecting article studies, online databases of national and international journals were searched. The databases for this study are Google Scholar, National Council of Higher Education Thesis Center in Türkiye, Dergipark, Resarchgate, Proquest, Academia, Adudspace, Sources from Universites in Türkiye, E- Resources at Harran University, EJER, Openaccess.hku. Scale studies conducted between 2018 and 2023, which encompass preschool education, educators, parents, and preschool resources, were searched. In total, 63 article studies were included in this content analysis (**Figure 1**). These studies were categorized as either scale development or scale adaptation. In recent years, research and scale studies, especially related to education and preschool education, have seen an increase in interest. To understand the types of scales that have been studied in recent years, a search was conducted for the last six years up to the present day.

Data Collection Tools

For data collection, a data collection form was prepared for content analysis, inspired by the 'Publication Classification Form' (Sözbilir, Kutu, and Yaşar, 2012), which was used to conduct a detailed scanning process. The form included categories such as whether the electronic document was a thesis or an article, the title of the article or thesis, the number of authors, the type of

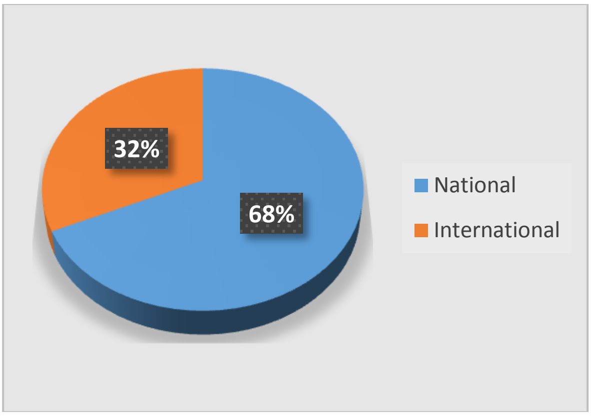

Figure 1. National/International Scale Development Studies in Preschool Education.

the study, whether the journal publication was national or international, information about the journal, journal index, study field, research method, data collection tools, information about the sample, and data analysis method. The study exclusively included works related to the preschool period and education. In the form, researchers directly filled in the information as available, without general sub categorization.

Data Analysis Process

A comprehensive search was conducted by both researchers to ensure the reliability of the scanning process. In cases where there was uncertainty about certain studies, the researchers came together to discuss and conduct further in-depth research, reaching a consensus and providing a sound solution. The authors worked collaboratively to classify the studies. The data obtained for content analysis were recorded in an online database, creating a platform accessible to both researchers at any time for their work. In the prepared table, the researchers checked for any missing data or instances where a single study may have been recorded multiple times. After the necessary checks, content analysis of the data was performed, and the percentages and frequencies were presented in tabular form in the study.

Findings

This section presents the results of a content analysis of articles in Turkey from 2018 to 2023 that focus on the development and adaptation of scales related to early childhood education. As doing this; number of the authors, type of the scale studies, indexed journals for articles, scale development

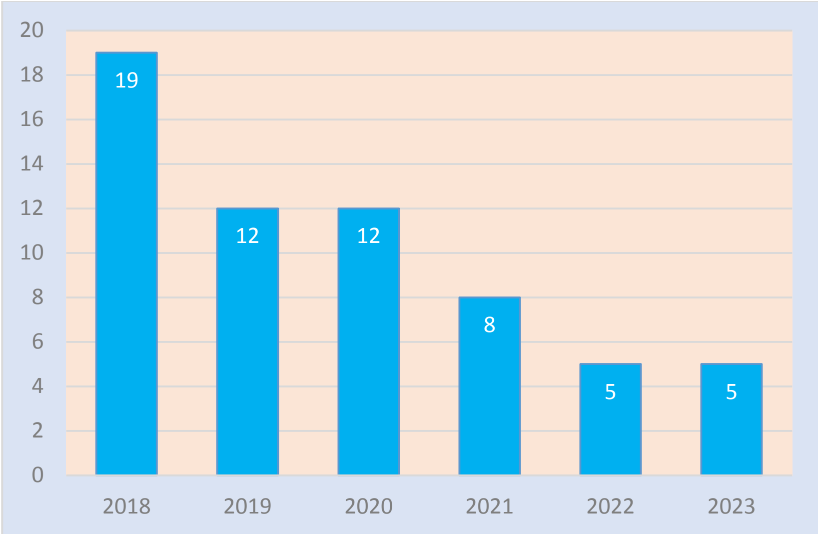

Figure 2. Distribution of Preschool Scale Development Publications by Years.

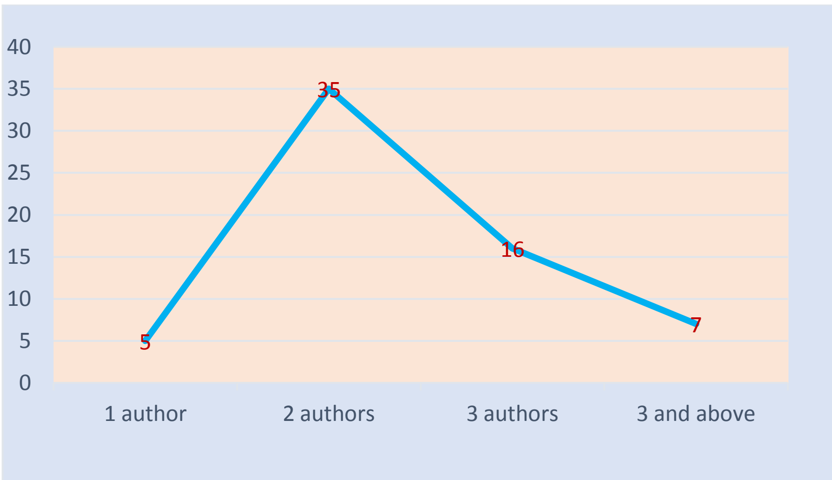

Figure 3. Number of Authors Involved in the Studies.

issues, research methods employed, sample and sample sizes and used analysis methods were given in this section. The findings are presented in a descriptive manner with the aid of tables and graphs. Titles have been created considering the research questions while presenting the findings and information is provided under these titles.

In this study, a total of 63 publications related to scale development and adaptation in articles concerning the early childhood period by Turkish researchers were examined through content analysis methods over the past six years.

Distribution of Publication by Years

Upon examining the **Figure 2** above, it is revealed that the number of preschool scale development publications has decreased from 2018 to 2023.

Number of the Authors

Figure 3 shows the number of authors in publications covering pre-school education in Turkey in the last 6 years. As can be seen in **Figure 3**, it was discussed that studies were mostly conducted with 2 authors (f = 35), and later studies were conducted with 3 authors (f = 16). It has also been observed that, although rare, studies have been conducted with 1 author (f = 5) and 3 or more authors (f = 7).

Type of Scale Studies

Figure 4 shows the type of scale development studies in preschool education. In this study, when the types of scale studies in articles related to the early childhood period from 2018 to 2023 were examined, it was revealed that out of 63 articles, 40 were focused on scale development, and 23 were dedicated to scale adaptation. When looking at scale adaptation and development studies related to the early childhood period between 2018 and 2023, it is revealed that the most commonly utilized data collection instrument, which was used in 63 articles, is the "Likert" data collection tool. All scale studies were done by Turkish authors.

Indexed Journals for Articles

Figure 5 shows the distribution of scale development studies in preschool education according to indexes. When the article studies related to the early childhood period from 2018 to 2023 are examined, it is evident that articles have been published in SSCI, ULAKBİM SBVT, and other indexes. ULAKBİM SBVT is a national index developed by Turkish Academic Network and Information Center for Social Sciences. ULAKBİM is most prominently featured in the scale development and adaptation studies, with 49 articles, while SSCI is represented in 2 articles focusing on scale development and adaptation. Other indexes are also present in 12 articles dedicated to scale development and adaptation studies.

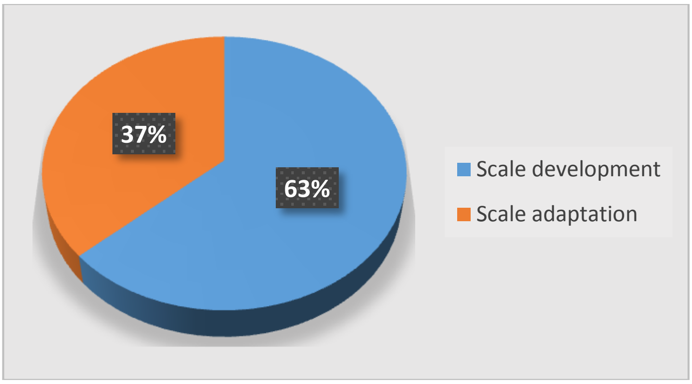

Figure 4. Type of Scale Development Studies in Preschool Education.

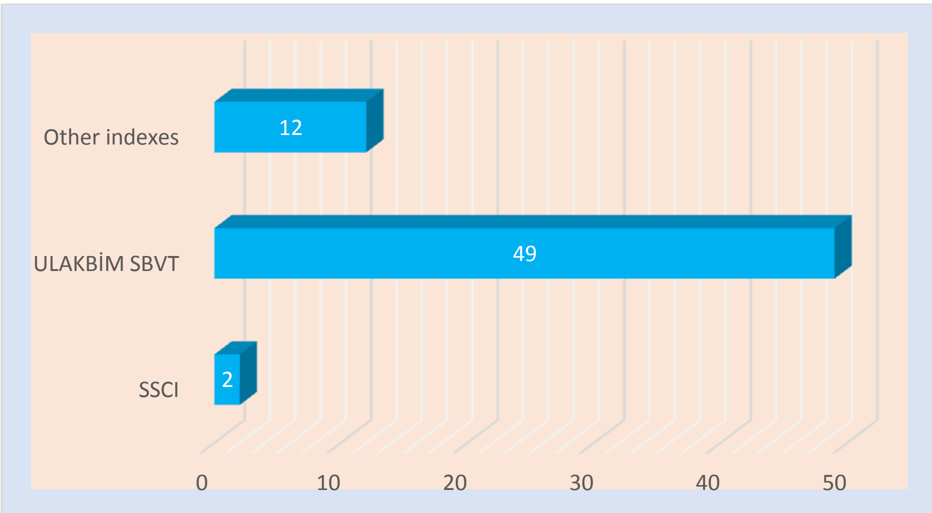

Figure 5. Distribution of Scale Development Studies in Preschool Education According to Indexes.

Scale Development Issues in the Study

Figure 6 provides the themes created about scale development issues in the articles as a result of the content analysis. When looking at **Figure 6**, it is evident that studies related to the early childhood period cover a wide range of different fields. Thus, 14 themes were created.

Table 1 contains the codes for the study subject under each theme. As can be seen in **Table 1**, it was determined that the most studied topics were related to the social emotional domain (f = 16) and later studies on, science education (f = 7), professional topic (f = 6, interaction, psychology (f

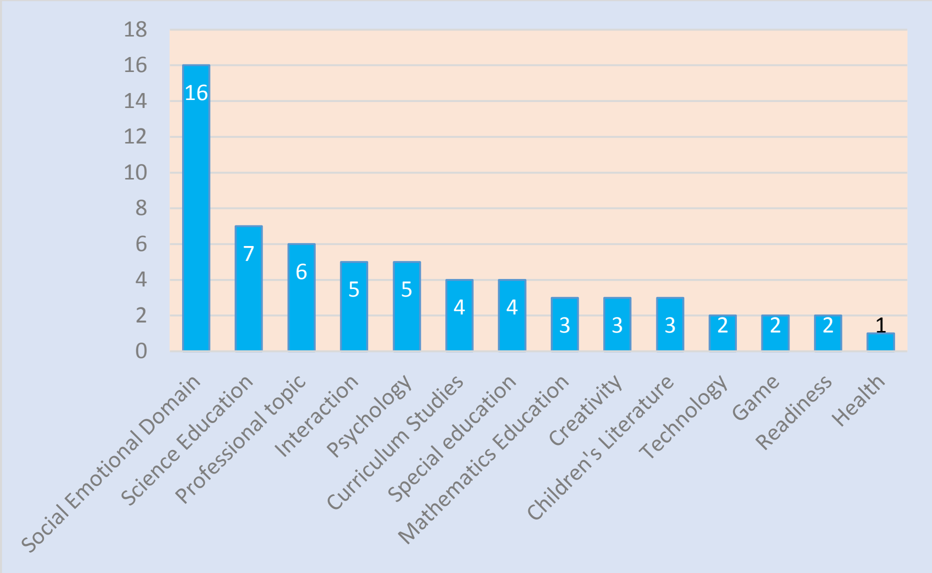

Figure 6.Themes of Scale Development Issues in Preschool Education.

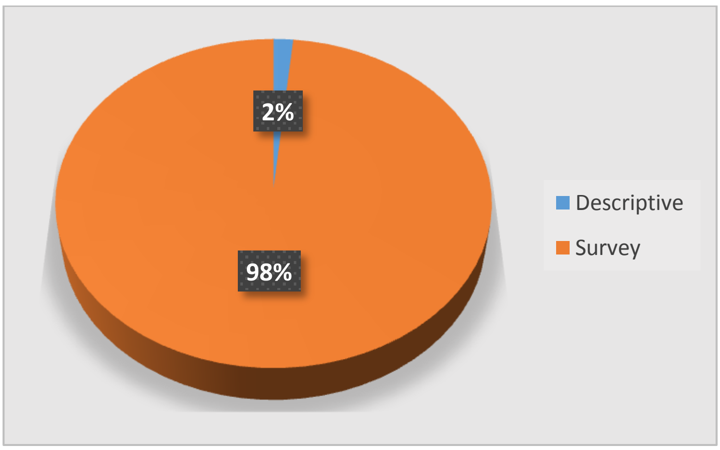

Figure 7. Research Methods in Preschool Education.

= 5), curriculum studies, special education (f = 4), mathematics education, creativity, children’s literature (f = 3), technology, game, readiness (f = 3)and health (f = 1) were followed respectively. The topics studied in scale development in preschool education can be examined in detail in **Table 1**.

Table 1. Survey Topics in Preschool Education.

	Social Emotional Domain	**f**		**Psychology**	**f**
1	Social skills scale	1	1	Child abuse	1
2	Teachers' executive function skills of children	1	2	Adolescent and child mental health	1
3	Determining self-efficacy regarding self-regulated teaching	1	3	Psychological well-being	1
			4	Adjusting to divorce	1
4	Measuring social behavior	1	5	Working memory	1
5	Feelings about school scale	1		*Subtotal*	5
6	Preschool teachers' beliefs in supporting self-regulation skills	1		**Curriculum Studies**	
			1	Curriculum evaluation	3
			2	Curriculum literacy	1
7	Social-emotional development assessment	1		*Subtotal*	4
				Special education	
8	Social emotional well-being and psychological resilience	1	1	Candidate reporting scale for gifted children	1
9	Child depressive symptom assessment		2	Perception of gifted education	1
10	Self-efficacy of inclusive classroom teachers	1	3	STEM education self-efficacy scale for gifted students	1
11	Social skill development	1	4	The impact of integration on children with special needs	1
12	Independent learning behaviors				
13	Determining the level of responsible behavior	1		*Subtotal*	4
14	Anxiety-fear scale	1		**Mathematics Education**	
15	Self-Regulation skill	1	1	Math skill	2
16	Responsibility training	1	2	Mathematics liking scale	1
Subtotal		16		*Subtotal*	3
	Science Education			**Creativity**	
1	Science education/training self-efficacy	3	1	Creative learning environment evaluation	1
2	View on science education	1	2	Creativity in teaching	1
3	Connecting with science/nature	1	3	Tendency to think innovatively	1
4	Scientific process skills	1		*Subtotal*	3
5	Self-efficacy for conducting scientific field trips	1		**Children's Literature**	
			1	Violent language in children's literature	
Subtotal		7	2	Competence in using digital story tools	1
	Vocational Training		3	Evaluation scale for illustrated story books	1
1	Teacher leadership	1		*Subtotal*	3
2	Love of profession	1		**Technology**	
3	Measuring unemployment anxiety	1	1	Children's use of technology	1
4	Teachers' attitudes towards evaluation-assessment	1	2	Technology addiction	1
5	Perceptions of the flipped learning model	1		*Subtotal*	2
				Game	
6	Attitude towards inclusive education	1	1	Risky games	1
Subtotal		6	2	Game perception	1
	Interaction			*Subtotal*	2
1	Teacher-child interaction	1		**Psychomotor**	
2	Family involvement	1	1	Gross and fine motor development	1
3	Co-parenting scale	1	2	Determining readiness	1
4	Early childhood parent media mediation	1		*Subtotal*	2
5	Teacher-student relationship scale	1		**Health**	
	Subtotal	5	1	Post-surgery pain	1
				Subtotal	1
Total Frequency					**63**

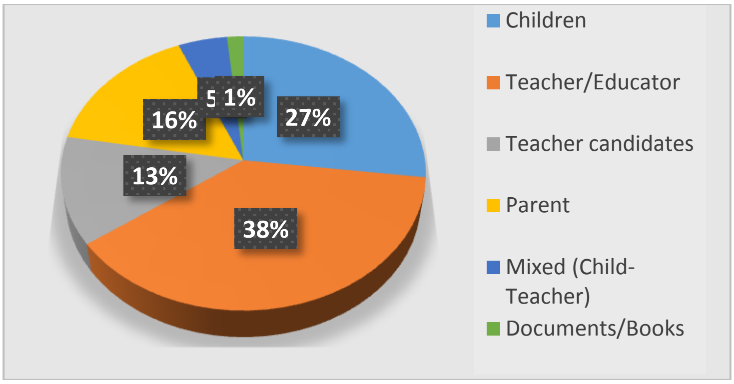

Figure 8. Frequently Studied Samples in Studies for Preschool Education.

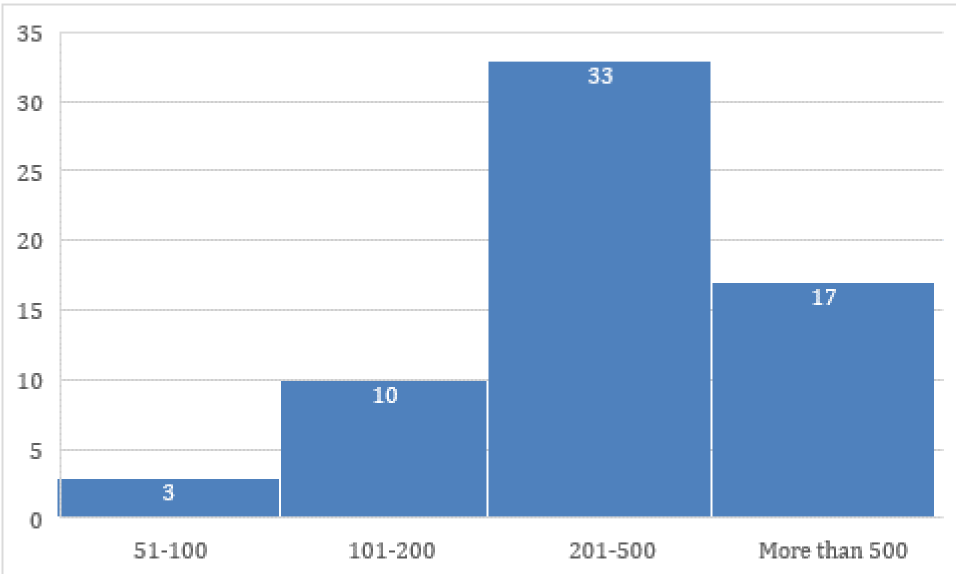

Figure 9. Frequently Studied Sample Sizes in Studies for Preschool Education.

Research Methods Employed in the Study

Figure 7 below presents the research methods employed in articles by Turkish researchers on scale development and adaptation in early childhood education from 2018 to 2023. When examining the research methods of the

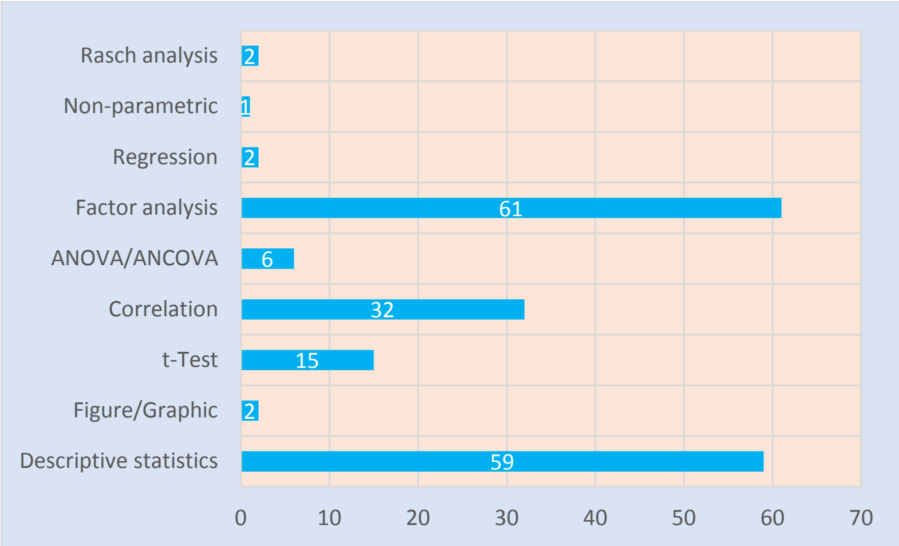

Figure 10. Analysis Methods Used in the Study.

studies, it is revealed that 62 studies used the survey method, 1 study chose the descriptive method.

Sample and Sample Sizes in the Study

Figure 8 shows the frequently studied samples in studies for preschool education. When examining the samples in scale development and adaptation studies in **Table 1**, it appears that there is diversity in terms of the samples. The studies have utilized samples consisting of preschool children, educators/teachers, teacher candidates, parents/guardians, documents/books, and mixed samples of children/teachers and children/parents. Among these samples, educators/teachers constitute the largest group with a total of 24 studies. The second-largest group consists of samples of preschool children, with 17 studies in terms of sample size. In the 3rd place, there are 10 studies that utilized a sample of parents/guardians. Looking at the 4th place, it is evident that a sample of teacher candidates is represented by 8 studies. In the 5th place, a mixed sample of children/teachers is represented by 3 studies. In the 6th place, there are an equal number of samples in a mixed sample consisting of 1.

Figure 9 shows frequently studied sample sizes in studies for preschool education. When considering the sample sizes, it becomes apparent that the majority of the samples, specifically 33 studies, fall within the range of 201-500. More than 500 samples are included in 17 studies.

There are 10 studies with sample sizes ranging from 101 to 200, and 3 studies with sample sizes ranging from 51 to 100.

Analysis Methods Used in the Study

Figure 10 shows analysis methods used in the study. When examining scale adaptation and development studies related to the early childhood period from 2018 to 2023, it is apparent that 59 articles utilized descriptive statistics, 2 articles employed graphical and visual methods, 15 studies used t-tests, 32 studies used correlation analysis, 6 studies used ANOVA and ANCOVA, 61 studies conducted factor analysis, 2 studies used regression analysis, 1 studies employed non-parametric methods and n2 studies utilized Rasch Analysis. Some articles employed multiple analysis methods instead of just one analysis method.

Conclusion and Discussion

In the research, scale development and adaptation studies related to the early childhood period are predominantly found in ULAKBİM-based indexes, accounting for 77.78 %. Only 3.17% of these studies are present in SSCI-based indexes, while 19.05% are associated with other indexes. Of the conducted studies, 43 are published in national journals, and 20 are published in international journals. This means that 68% of scale studies are indexed nationally, and 32% have international index coverage.

When examining scale adaptation and development studies related to the early childhood period, it is evident that the density of research topics primarily includes areas such as mathematics education, preschool programs, science, technology, game, social-emotional development, children’s literature, and special education, among others. From this, it can be stated that there is a rich diversity in the field of study. It is also observed that cognitive development studies encompassing social-emotional development and mathematics and science are more frequently employed in scale development and adaptation research.

Data indicates a decline in the number of publications on preschool scale development between 2018 and 2023. The reason of this can be difficulties and taking more time and resources for developing or adapting a scale. The process of cross-cultural adaptation involves detailed translation and adaptation procedures to ensure the accuracy and cultural sensitivity of scales, which requires time and resources (Beaton & et al., 2000). Trends in scale development in preschool education are generally social emotional domain and science education. There can be many reasons for it. Some of them can be:

Education Policies and Needs: In Turkey, social-emotional development and science education are considered crucial areas in preschool education. Therefore, assessment scales are used in these areas to monitor and evaluate children's development.

Research and Development Studies: These scales have been developed by educators, psychologists, and researchers and adapted to meet local needs in Turkey's preschool education environment.

Importance Given to Early Childhood Education: The preschool period is crucial for children to develop fundamental skills and acquire social-emotional abilities. Hence, assessment scales focusing on this period are considered critical for monitoring children's overall development.

Practitioners' Needs and Requests: Teachers and other professionals in preschool education may require assessment scales to track children's development and guide educational strategies.

Considering the development of children in Turkey, the environment they live in, and the conditions of the century they live in, there is a significant need for these areas, or it may be due to the lack of many studies in this field.

Scale development and adaptation in preschool education involve specific considerations to ensure the validity and reliability of measurement tools tailored for young children. There are important key considerations in preschool education like:

Developmental Appropriateness: Ensuring that the items and scales are developmentally appropriate for preschool-aged children, considering their cognitive, emotional, and social development (Pianta & Nimetz, 1991).

Language and Communication: Adapting scales to be language-sensitive and suitable for young children's communication abilities, often involving simplified language and visual aids (La Paro, & Pianta, 2000).

Observational Methods: Utilizing observational methods alongside parent or teacher reports to capture preschoolers' behavior and development comprehensively (Howes & Ritchie, 1999).

Cultural Sensitivity: Ensuring scales are culturally sensitive and relevant, especially in diverse preschool settings, through adaptation and validation processes (Landry & et al., 2002).

Parent and Teacher Involvement: Involving parents and teachers in the scale development process to ensure that the items and scales reflect their observations and concerns (Berry & et al., 2001).

The impacts of scale development and adaptation on preschool education practice and research are multifaceted and significant. Developing and adapting scales for preschool education can enhance the accuracy and reliability of assessments, leading to improved educational practices and outcomes. The importance of scale development or adaptation for the preschool period can be listed as follows:

- **Increased Assessment Accuracy**: The development of reliable and valid scales ensures that the assessment of preschool children's skills, behaviors, and development is accurate. This allows educators to identify children's strengths and areas needing support more effectively (AERA, APA, & NCME, 2014).
- **Tailored Educational Interventions**: Accurate scales help in designing targeted interventions that address specific needs of preschool children. By using data from these assessments, educators can create personalized learning plans that support each child's development (Gullo, 2005).
- **Improved Educational Outcomes**: Adapted scales that are culturally and contextually relevant contribute to better educational outcomes. They ensure that the assessments are meaningful and applicable to the children being assessed, thus improving the quality of education they receive (Maxwell, Clifford, & Guralnick, 2015).
- **Informed Policy Making**: Reliable data from well-developed scales can inform policy decisions at various levels. Policymakers can use this data to develop and implement policies that support early childhood education and address gaps in the current system (Snow & Van Hemel, 2008).
- **Advancement of Research**: Scale development and adaptation contribute to the advancement of research in preschool education. Valid and reliable scales are essential for conducting high-quality research, which can lead to new insights and improvements in educational practices (Pianta, Barnett, Justice, & Sheridan, 2012).
- **Cultural Sensitivity and Inclusivity**: Adapted scales that take into account cultural differences ensure that assessments are fair and inclusive. This is particularly important in diverse educational settings, where a one-size-fits-all approach may not be effective (Rogoff, 2003).

Additionally, it has been revealed that scale development and adaptation studies related to art have not been addressed in recent years. In areas such as physical development, game, and readiness, there is also a limited number of studies in terms of scale development and adaptation. Despite the exploration of various topics related to the early childhood period, with the exception of studies in children's literature, there have been few scale development studies related to language development in the last six years. The reasons for this could be a subject for further research. Possible explanations may include the extensive prior work in this area or a decrease in recent attention to research in this field.

When looking at language development, it is argued that it is closely intertwined with humans and society, and it plays a significant role in the formation of fields such as culture, art, and science (Aksan, 1998). When early childhood education programs incorporate language and cognitive development, they can make a substantial contribution to the early childhood period (Aydoğan and Koçak, 2003). It can be said that early childhood education is not only important for children but also holds a significant place for their families and the society in which they live (Güven and Efe-Azkeskin, 2010). Therefore, the development and adaptation of scales are crucial for monitoring the progress and advancement of children and all individuals and fields related to children. This way, it becomes possible to swiftly and reliably assess where there are deficiencies, which aspects need further improvement, and which areas have advanced more.

When examining scale studies that encompass the preschool period, reviews have been conducted on scales related to early childhood, although these scales have predominantly taken into account only one aspect of a child's development. For example, Kay and Sağlam (2020) examined scales used to measure social and emotional development in children. The study not only covered the preschool period but also encompassed broader age groups. Additionally, the study spanned research conducted between 1987 and 2020.

Another example includes a document review of articles published in 21 different national journals between 2002 and 2013, which focused on the development and adaptation of assessment scales/achievement tests in the field of science education, specifically tailored to Turkish culture. This study conducted by Tosun and Taşkesenligil (2015) also encompassed middle and undergraduate-level research, rather than focusing solely on the preschool period.

When examining the conducted studies, it appears that there is a debate regarding whether qualitative or quantitative research is superior in the field of educational sciences (Hammersley, 1992). Descriptive surveys from quantitative studies seem to dominate the landscape in early childhood research, particularly in the last six years, as they constitute a significant majority of scale development and adaptation studies.For the sample of early childhood scale studies from the last six years (2018-2023), the participants are found to consist of educators/teachers, preschool children, parents/guardians, teacher candidates, mixed samples of children/teachers, mixed samples of children/parents, and documents/books.

The scale studies revealed that the largest samples were constituted by educators/teachers, while the smallest samples were formed by children/parents and documents/books.

Guadagnoli and Velicer (1988) argued that the absolute number of observations is a standard measure, and an adequate number of observations should typically range between 100 and 200. Aleamoni (1976) proposed that a suitable sample size for factor analysis is 400, a view supported by Guadagnoli and Velicer (1988). Comfrey and Lee (1992) categorized the absolute number of observations as follows: 50 (very weak), 100 (weak), 200 (moderate), 300 (good), 500 (very good), and 1,000 and above (excellent). When examining the scale studies, it was found that the sample sizes fell in the range of 201-500, which is from moderate to very good. There were only 3 studies with sample sizes ranging from 51 to 100, indicating very weak to weak samples. No scale adaptation and development studies were found with sample sizes of 1,000 and above or sample sizes below 50.

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Received: June 13, 2024
Revised: June 22, 2024
Accepted: July 16, 2024

ORIGINAL ARTICLE

Preservice Science Teacher Attitudes towards the Reconceptualized Family Resemblance Approach to the Nature of Science

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Abstract: *This study aimed to determine preservice science teachers' (PST) attitudes towards the Reconceptualized Family Resemblance Approach to the Nature of Science and to examine PST attitudes towards this approach according to grade levels. The study group consists of 75 people studying in the 3rd and 4th year of undergraduate education. The sample of the study was determined through 'purposive sampling'. The screening model, one of the quantitative research methods, was used in the research. The questionnaire consists of 70 items and 6 categories. The Cronbach's Alpha value of the scale, for which the reliability study was conducted, was determined as 0.73. To examine the distribution of the data, the Shapiro-Wilk test was performed as a normality test and the kurtosis and skewness values of the data were read. Independent sample t-test was applied on normally distributed 3rd and 4th grade PST data. According to the findings, it was determined that the PST was above the average and had a positive attitude. Although there is a difference between PST perspectives at two different grade levels for two questions of the scale, there is no significant change among PST for the entire performance.*

Science Insights Education Frontiers 2024; 25(2):4145-4161
DOI: 10.15354/sief.24.or668

How to Cite: Türkmen, H., & Yeğen, B. (2024). Preservice science teacher attitudes towards the reconceptualized family resemblance approach to the nature of science. Science Insights Education Frontiers, 25(2):4145-4161.

Keywords: *Family Resemblance Approach, Family Resemblance Approach Wheel, Nature of Science, Consensus View of Science Education*

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***Conflict of Interests**: None*

***Funding**: No funding sources declared.*

***AI Declaration**: The author affirms that artificial intelligence did not contribute to the process of preparing the work.*

Introduction

IN TODAY'S world, the importance given to science education has begun to increase again due to the growing needs of countries. Although it gained significant momentum about a decade ago, the emphasis that countries place on science education dates back much further. The competition between countries has intensified day by day, starting with the industrial revolution and continuing through the post-Cold War era, which marks a pivotal point close to the present day. Countries aiming to gain a competitive edge in this increasingly competitive environment have identified the inadequacy in science and mathematics learning as the root cause of developmental disruptions (Türkmen & Yalçın, 2001). Based on this realization, the objectives of science education have evolved over time. The goal now is to cultivate scientifically literate individuals, achieved through an understanding of the nature of science (Irzik & Nola, 2011). To foster scientific literacy, it is essential to comprehend scientific concepts and the essence of science education. Nonetheless, defining what science truly encompasses remains a topic of ongoing debate among scientists. Despite ongoing debates, the scientific community generally agrees on several aspects defining what science entails. One such perspective emphasizes that while scientific knowledge relies on experimentation and observation, it remains dynamic and subject to change. It integrates social and cultural elements, employing imagination and reasoning alongside observation, inference, theories, and laws. Another widely accepted view posits that the driving force behind science is curiosity, initiating a continuous and dynamic process. Furthermore, science is widely regarded as transcending political, geographical, and religious boundaries, welcoming diverse research and contributions (Türkmen & Yalçın, 2001). To achieve scientific literacy, individuals must possess specific attitudes, skills, and understandings. These include the ability to conduct research, question effectively, solve problems, make informed decisions, think critically, and continually engage in lifelong learning.

Science was born as a result of human beings' desire to satisfy their sense of curiosity by understanding the universe. Data obtained from experiments and observations can be verified and refuted by other researchers. While debates continue about the definition of science, some scientists argue that to understand what science is, it is necessary to understand what science is not. Addressing what science is not leads us to Pseudo-Science. Pseudo-Science mimics the methods and appearance of science, asserting that results obtained by chance and cannot be replicated should be considered scientific (Yardımcı, 2019). Proponents of this idea argue that alongside teaching the nature of science, it is crucial to explain what Pseudo-Science entails. However, merely informing students about

Pseudo-Science and advising them to avoid it is insufficient. When students seek to differentiate between examples of science and Pseudo-Science, they should be taught how to evaluate and analyze these examples from various perspectives. Teaching Pseudo-Science in this manner will also aid in understanding the nature of science (Park & Brock, 2023).

The aim of teaching the nature of science extends beyond imparting scientific subjects and laws. It includes exploring the historical development of these subjects and laws to help students understand the interdisciplinary aspects encompassing history, psychology, sociology, and philosophy of science, as well as the processes through which scientists arrive at these conclusions (Türkmen & Yalçın, 2001). However, merely defining the nature of science was deemed insufficient. The dynamic and multifaceted nature of science precludes creating a definitive checklist to determine what qualifies as science. In response, the consensus view was introduced to provide a generalized understanding of science based on commonly accepted scientific characteristics. While some scientists endorse this consensus view, others argue it oversimplifies science, particularly by neglecting the diverse methods used to acquire scientific knowledge. Critics also contend that it fails to acknowledge variations among scientific disciplines; for instance, the methodologies in non-experimental cosmology differ significantly from those in experimental chemistry. To address these limitations, the “Family Resemblance Approach” was proposed as a means to account for the diverse practices and methodologies within scientific disciplines (Irzik & Nola, 2011). The family resemblance approach builds upon the consensus view and examines the relationships between scientific categories within this framework (Dagher & Erduran, 2023). This approach represents an evolution of the consensus view rather than a contradiction, as it emphasizes similarities and differences among scientific disciplines (Irzik & Nola, 2011). It argues that scientific fields can resemble each other in certain respects, akin to a family, while also maintaining distinct characteristics. The approach advocates for categorizing scientific disciplines based on evolving criteria rather than rigid definitions. For instance, not all activities involving observation qualify as science, and conversely, some non-observational activities may still be considered scientific (Irzik & Nola, 2011). The family resemblance approach is applicable across undergraduate education, STEM curricula, and textbooks, aiming to integrate nuanced perspectives into teaching practices (Irzik & Nola, 2023). Effective implementation in educational settings necessitates comprehensive theoretical and practical in-service training for educators on the nature of science. Educators equipped with such training and readiness can effectively utilize all three primary structures in teaching the family resemblance approach (Kurt & Kaya, 2023).

The family resemblance approach forms a whole by connecting each of the 3 main structures with each other. These structures;

1. A cognitive-epistemic and social institution,
2. The category and feature of science that gives meaning to this distinction is
3. Different scientific disciplines create family resemblances.

Science is often categorized into two domains: cognitive-epistemic science and science as a social institution. Cognitive-epistemic science encompasses the processes involved in acquiring scientific knowledge, including observation, experimentation, theorizing, and testing. This aspect of science can be further analyzed through four dimensions: practices, goals and values, methods and methodological rules, and scientific knowledge. On the other hand, science as a social institution operates within a framework that includes systems of reward and punishment, ethical norms (such as respect for research subjects, openness to new ideas, and intellectual honesty), and the allocation of financial resources. While the family resemblance approach does not exclusively belong to a specific conceptualization of the nature of science, it is essential to consider all three structures cognitive-epistemic science, science as a social institution, and the family resemblance approach to gain a comprehensive understanding of the complexities of scientific practice (Irzik & Nola, 2023).

Shortly after scientists introduced the family resemblance approach, Erduran and Dagher undertook an examination and expanded it into a comprehensive framework (Irzik & Nola, 2011). In 2014, Erduran and Dagher further redefined the family resemblance approach to the nature of science and developed the ‘Family Resemblance Approach Wheel’ to organize its categories (**Figure 1**). According to this reconceptualization, cognitive-epistemic science is categorized into “aims and values,” “methods and methodological rules,” “scientific practices,” and “scientific knowledge.” Meanwhile, science as a social institution encompasses a total of 11 categories, including “scientific value systems,” “social validation and dissemination,” “professional activities,” “social values,” “financial systems,” “political power structures,” and “social institutions and interactions” (Erduran & Dagher, 2014).

When examining each category individually, within the cognitive-epistemic system of science, the goals and values category encompasses principles such as accuracy, objectivity, consistency, and rationality. Scientific practices include activities such as observation, classification, explanation, discussion, and reasoning. The methods and methodological rules category consist of observational, investigative, and analytical methods, along with their respective protocols. Scientific knowledge encompasses theories, laws, and models as examples. In terms of professional activities, scientists engage in participating in conferences, presenting findings, writing articles, developing grant proposals, and securing funding. Scientific values

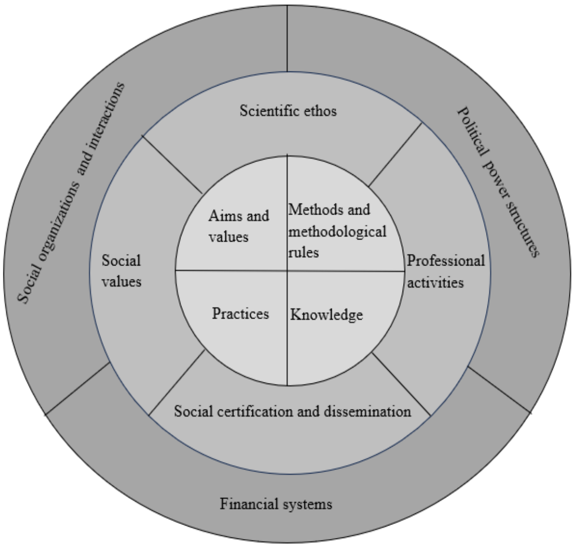

Figure 1. The Wheel of Family Resemblance: Science as a Cognitive-Epistemic and Social-Institutional System (*From Erduran & Dagher, 2014*)**.**

encompass elements such as skepticism, universality, impartiality, freedom, intellectual honesty, and respect for research subjects. Within the social institutional framework of science, the category of social validation and dissemination involves the critical review and community approval of scientific findings. Social values in science encompass considerations such as societal benefits, environmental respect, and power dynamics. Social institutions and interactions are exemplified by collaborations within research teams across different projects. Political power structures in science address how scientists navigate political environments to advance their research agendas. The financial systems category includes topics such as economic intermediation and funding within scientific endeavors (Dagher & Erduran, 2023). This summary organizes and describes each category within both the cognitive-epistemic and social institutional aspects of science as outlined by Dagher and Erduran (2023), aiming to provide a comprehensive view of the complexities involved in scientific practice.

The reason for applying the family resemblance approach in science education is its potential to support scientific reasoning in both scientific and social contexts (Dagher & Erduran, 2023). This potential makes teaching the reconceptualized family resemblance approach to the nature of science suitable for all grade levels. However, in this approach, teaching must be articulated vertically. Vertical articulation can be explained as the progressive advancement of teaching at each grade level, from simpler to more complex concepts. The nature of science is a field that facilitates students' understanding of science and guides teachers and researchers. However, teachers often struggle to incorporate nature of science teaching into their lessons, primarily due to the shortcomings of textbooks. The categories of the family resemblance approach should be clearly explained in textbook chapters. This alignment between content and activities can help students gain a deeper understanding of the nature of science (Okan & Kaya, 2023). Although these problems can be addressed through changes in the curriculum or through in-service training for teachers, it is also crucial to focus on preservice teacher education by delving deeper into the issue based on the existing literature, which highlights a number of studies conducted with preservice teachers.

One of the studies in the literature involves a workshop conducted by Cullinane and Erduran with Irish preservice science teachers in 2022. The study aimed to familiarize prospective teachers with the categories of the reconceptualized family resemblance approach to the nature of science and enable them to develop lesson plans accordingly. Following the workshops, it was observed that activities aligned with this approach positively impacted the interest and knowledge of prospective teachers. Their motivation increased, and although they varied in levels of proficiency, prospective teachers showed improvement in integrating the approach's categories into their lessons. Similarly, Barak et al. (2023) suggested that encouraging preservice teachers to draw or verbally and in writing explain their understanding could help them articulate what they have learned and how they intend to convey it. In another study by Voss et al. (2023), it was emphasized that teaching the family resemblance approach should not only equip preservice teachers with the skills to teach the nature of science but also guide them in helping students connect these criteria to various aspects of science. Erduran et al. (2021) conducted a comparative study with Turkish and British preservice teachers to evaluate their perception of the family resemblance approach in different national contexts. They found that group discussions facilitated understanding of the approach's categories among prospective teachers and suggested that teaching family resemblance to secondary school students could similarly benefit from group discussions. Lastly, Wu and Erduran (2024) examined scientists' perspectives on the family resemblance approach, noting that while scientists could elaborate on cognitive-epistemic aspects, their explanations regarding the social institutional aspect were often inadequate based on data from open-ended interviews.

Teaching the nature of science begins with formulating widely accepted general explanations and culminates with the family resemblance approach (Irzik & Nola, 2023). Given that the primary goal of science education is to cultivate scientifically literate individuals, teaching the nature of science becomes imperative. The family resemblance approach to the nature of science contributes to this goal directly and indirectly supports the development of scientific literacy. Therefore, the attitudes of preservice science teachers, who will shape the scientific literacy of future generations, toward the family resemblance approach are crucial. While there are existing studies on the application of the family resemblance approach in the literature, there is a lack of model studies specifically examining attitudes toward different grade levels. Consequently, the main objective of this study is to assess the attitudes of prospective science teachers toward the reconceptualized family resemblance approach to the nature of science and to compare these attitudes across various grade levels. To achieve this goal, the study seeks answers to the following questions:

RQ 1. What is the level of pre-service science teachers' attitudes towards the reconceptualized family resemblance approach to NOS?
RQ 2. Is there a significant difference between preservice science teacher attitudes towards the reconceptualized family resemblance approach to the nature of science according to their grade levels?

Method

Research Design

In this research, which aims to examine the attitudes of 3rd and 4th grade science education students toward the family resemblance approach to the nature of science, the screening model, one of the quantitative research methods, was employed. The purpose of this method is to describe and uncover the current situation (Büyüköztürk et al., 2020).

Study Group

While the population of the research consists of all students in the Science Teaching Program studying at the Faculties of Education in Turkey in the 2023-2024 academic year, the sample was selected from 3 universities located in one of the metropolitan cities in Turkey, which was in line with the purpose. A total of 84 Science students, 38 (48.7%) of whom were third-year undergraduate students and 40 (51.3%) of whom were fourth-year undergraduate students, were selected through 'purposive sampling'' to form the study group in the Science Teaching Program of the Faculty of Education at the selected university. His knowledge is that of a preservice teacher. When the incorrectly filled scales were eliminated, the final study group was conducted with a total of 75 preservice science teacher, 37 of whom were from the third grade (49.3%) and 38 from the fourth grade (50.7%).

Table 1. Positive and Negative Items on the Scale (Kaya et al., 2019)

Category	Example	#	Positive and Negative Items in the Scale: Positive	Negative
Aims and Values	*The diversity of scientists solving a problem together means less biased results. (Positive item)*	7	2,30,40,5,1,69	46.56
Scientific Practices	*Each branch of science has a different nature. (Positive item)*	13	4,5,15,19,23,33,38 57,61, 63	26,52,64
Scientific Method	*Different branches of science such as physics, biology and chemistry have the same applications. (Negative item)*	9	11,22,24,28	8,25,37,49, 60
Scientific Knowledge	*Scientific knowledge does not change. (Negative item)*	9	10,30,44,50, 54	3,16,43,66
Social Institutional Aspects	*Scientists must respect the environment. (Positive item)*	16	7,9,14,32,34,41 45,48,53,58,67,70	13,18,36,39
Educational Applications	*Science teaching should state that laws are certain and unchangeable. (Negative item)*	16	1,6,12,17,21,27,29 31,42,55,59,62,65	35,47,68

Purposive sampling includes individuals who have certain characteristics and are most suitable for the purpose of the research (Büyüköztürk et al., 2020). The reason for working with undergraduate third and fourth grade preservice science teacher within the scope of the study is that the preservice teacher at these grade levels is taking or have taken courses such as laboratory practices, interdisciplinary science teaching, and the nature and teaching of science throughout the process, in order to have cognitive competence about the nature of science (The Council of Higher Education, 2018).

Data Collection Tools

Reconceptualized Family Resemblance Approach to Nature of Science (RFN)' scale, developed by Kaya et al. in 2019, was used as a data collection tool in the study. The name of the scale has been translated as the 'Reconceptualized Family Resemblance Approach to the Nature of Science (FRA)' scale. Since the original language of the scale is English, a Turkish translation study was made. During the adaptation process of the translation study, help was received from expert researchers and its linguistic validity was checked.

The scale is a five-point Likert-type attitude scale consisting of 70 items and response groups of 'Strongly Disagree (1), 'Disagree (2)', 'Not Sure (3)', Agree (4)' and 'Strongly Agree (5)'. There are 6 categories in the scale (Aims and Values, Scientific Practices, Scientific Method, Scientific Knowledge, Social-Institutional Aspects, Educational Applications) and while the positive items were scored as 5,4,3,2,1, reverse coding was done to score the negative items. The scale contains 49 positive and 21 negative items. Exploratory factor analysis was performed to determine the validity of the scale and the

KMO value was found to be 0.714. The scale consists of 6 categories. These categories; Aims and Values, Scientific Practices, Scientific Method, Scientific Knowledge, Social Institutional Aspects and Educational Practices (**Table 1**).

When the average of the answers given by the preservice teacher to the scale was examined, the value was found to be 3.59. This value was evaluated according to the table prepared for the five-point Likert-type scales in Bukhari's 2023 study. According to the table ' The Internal Level of the 5-Point Likert Scale' in this study ; The arithmetic mean value in the range of 1-1.80 points is 'Strongly Disagree', the arithmetic mean value in the range of 1.81-2.60 points is 'I Disagree', the arithmetic mean value in the range of 2.61-3.40 points is 'Neutral', the arithmetic mean value in the range of 3.41-4.20 points corresponds to the statement 'I Agree', and the arithmetic mean value in the range of 4.21-5.00 points corresponds to the statement 'Strongly Agree'.

The value of 3.59 found in this study corresponds to the score range of the statement 'I Agree' since it is in the range of 3.41-4.20. Accordingly, if the arithmetic mean of the preservice teacher for the questions in the scale items is above 3.41, their attitudes will be considered above average. The reliability study of the scale was conducted and the Cronbach's Alpha value for the entire scale was found to be 0.73. The reliability coefficients of the scale categories vary between 0.71 and 0.77. A reliability coefficient of 0.70 or higher is considered sufficient (Büyüköztürk, 2020).

Application Process

Since the aim of the study was to examine the attitudes of prospective science teachers towards the reconceptualized family resemblance approach to the nature of science and the changes in these attitudes according to grade levels, the study group was determined first. The 'Reconceptualized Family Resemblance Approach to the Nature of Science' scale, the data collection tool whose adaptation process was completed with language validity, was reproduced according to the sample size and distributed to 3rd and 4th year undergraduate students in the classroom environment at appropriate times. The process of students completing the scale took an average of 15-20 minutes.

Data Analysis

The data of the research were collected in the fall semester of the 2023-2024 academic year. The data were obtained from the preservice teacher responses to the scale and analyzed with the SPSS 25 program. To determine the technique to be used in data analysis, the normality test (**Table 2**) was first

Table 2. Normality Test.

	Kolmogorov-Smirnov			Shapiro-Wilk		
Grade Level	Statistics	df	p	Statistics	df	p
3rd Grade	0.106	37	0.200	0.978	37	0.675
4th Grade	0.068	38	0.200	0.974	38	0.512

Table 3. Independent Sample T-Test Results for the RFN Scale.

	Grade Level	n	x̄	sd	df	t	p
FRA	3rd grade	37	3.6146	0.18999	73	1.105	0.273
	4th grade	38	3.5709	0.14999			

performed. Since the number of participants in both groups was less than 50, the Shapiro-Wilk test was taken into account (Büyüköztürk, 2020).

Shapiro-Wilk test was calculated separately for third (p = 0.675 p > 0.05) and fourth (p = 0.512 p > 0.05) undergraduate grades. As a result of the normality test, kurtosis and skewness values were read. The kurtosis value (0.155), skewness value (0.811) for third-year undergraduate students, and the kurtosis value (-0.576) and skewness value (1.194) for fourth-year undergraduate students are between ±1.5, indicating that the data is normally distributed (Tabachnick and Fidell, 2013).

Results

This section includes the quantitative findings of the analyzed data regarding the "Reconceptualized Family Resemblance to the Nature of Science (FRA)" scale. Independent sample t-test analysis was conducted to reveal whether there was a significant difference between the attitudes of third and fourth grade preservice science teacher towards the reconceptualized family resemblance approach to the nature of science. As a result of the test, there was no statistically significant difference between third and fourth grade preservice science teacher RFN attitudes, t (73) = 1.105, p > 0.05. While the arithmetic mean value of the third graders was found to be 3.61, the arithmetic mean value of the fourth graders was found to be 3.57 (**Table 3**).

Since there was no significant difference between grade levels in the overall scale, 6 categories and 70 items in the scale were examined one by one. Aims and Values; t (73) = -1.386, p < 0.05, Scientific Practices; t (73) =1.136, p < 0.05, Method; t (73) =1.954, p < 0.05, Scientific Knowledge; t (73) = -5.37, p < 0.05, Social-Institutional Aspects; t (73) = 0.912, p < 0.05

Table 4. Independent Sample T-Test Results for RFN Scale Questions.

Question 46: Scientific facts are not affected by the prejudices and individual subjective prejudices of scientists.

	Category	Grade Level	n	x̄	ss	df	t	p
Question 46	Aims and Values	3rd Grade	37	2.2162	1.03105	73	-3.223	0.002
		4th Grade	38	3.0526	1.20690			

Table 5. Independent Sample T-Test Results for RFN Scale Questions.

Question 24: Diversity of methods contributes to scientific understanding.

	Category	Grade Level	n	x̄	ss	df	t	p
Question 24	Method	3rd Grade	37	4.4595	0.50523	73	3.387	0.001
		4th Grade	38	4.0000	0.665760			

and Educational Applications; As a result of examining 6 categories as t (73) = 1.023, $p < 0.05$, no significant difference was found between third and fourth grade levels in any category.

In the following process, analysis was made for each question in the scale. According to the analysis results, questions with a significant difference between the two grade levels in the scale are included in this section. In the 46th question belonging to the purpose and values category, a significant difference was observed between the RFN attitudes of the third and fourth graders. t (73) = -3.223, $p < 0.05$. The arithmetic mean of the third graders was 2.21, and the arithmetic mean of the fourth graders was 3.05 (**Table 4**). This revealed that there was a statistically significant difference in the attitudes of third and fourth grade preservice science teacher towards the 46th question towards the 4th graders.

In the 24th question of the method category, a significant difference was observed between the third and fourth graders' attitudes towards FRA, t (73) = 3.387, $p < 0.05$. While the arithmetic mean of the third graders was found to be 4.45, the arithmetic mean of the fourth graders was found to be 4.00 (**Table 5**). This revealed that there was a statistically significant difference in the attitudes of third and fourth grade preservice science teacher towards the 24th question towards the 3rd graders.

A column chart was created for the arithmetic means of the items of the scale (**Figure 2**). According to the table 'The Internal Level of the 5-Point Likert Scale' in Bukhari's study in 2023, values were assigned to the x-axis and the column chart was completed. According to the table in

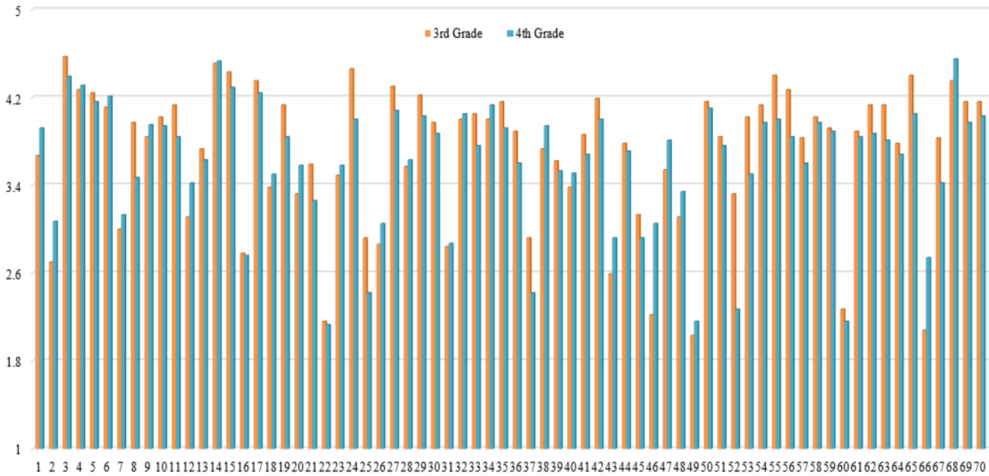

Figure 2. Number of Items Corresponding to Attitude Score Ranges.

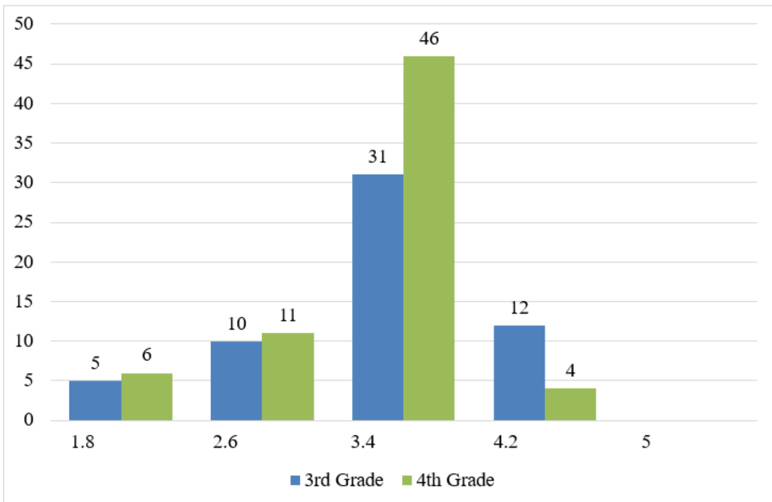

Figure 3. Number of Items Corresponding to Attitude Score Ranges.

Bukhari's study, there are no items in the scale between 1-1.80 that belong to the attitude of 'Strongly Disagree'. The scale includes 5 items in the 3rd grade, 6 items in the 4th grade, and 3 items (22, 49, 60) that are common to both grade levels, regarding the 'Disagree' attitude, in the range of 1.81-2.60. The scale includes 11 items belonging to the 'Neutral' attitude in the 3rd grade, 10 items in the 4th grade, and 5 items (2, 7, 16, 26, 48) that are common to both grade levels, in the range of 2.61-3.40. In the scale, there are 31 items belonging to the 'I Agree' attitude in the 3.41-4.20 range, 31 items in the 3rd grade, 10 items in the 4th grade and 29 items common to both grade levels (1, 5, 6, 9, 10, 11, 13, 19, 23, 28, 32, 33, 34, 35, 36, 38, 39, 41, 42, 44, 47, 50, 53, 54, 58, 62, 63, 69, 70).

The scale includes 12 items in the 3rd grade, 4 items in the 4th grade, and 4 items (4, 14, 15, 68) that are common to both grade levels, belonging to the 'Strongly Agree' attitude, in the range of 4.21-5.00 (**Figure 3**). The attitude in which preservice teacher arithmetic average scores of the items in the scale are most concentrated is the 'I Agree' attitude. Among the 3rd grade preservice science teacher in the entire scale, the 3rd item belonging to the 'Scientific Knowledge' category has the highest arithmetic mean ($\bar{x}$= 4.57), while the 49th item belonging to the 'Method' category has the lowest arithmetic mean ($\bar{x}$= 2.03) has. Among the 4th grade preservice science teacher in the entire scale, the 68th item belonging to the 'Educational Applications' category has the highest arithmetic mean ($\bar{x}$= 4.55), while the 22nd item belonging to the 'Method' category has the lowest arithmetic mean ($\bar{x}$ = 2.13). The arithmetic averages of the categories vary according to grade levels. In the Aims and Values category, the arithmetic average of 3rd grade preservice teacher is 3.41, while 4th grade students' mean is 3.51. In the Scientific Practices category, the arithmetic average of 3rd grade preservice teacher is 3.92, while the arithmetic average of 4th grade students is 3.83. In the Method category, the arithmetic average of 3rd grade preservice teacher is 3.06, while the arithmetic average of 4th grade students is 2.90. In the Scientific Knowledge category, the arithmetic average of 3rd grade preservice teacher is 3.56, while the arithmetic average of 4th grade students is 3.60. In the Social Institutional Aspects category, the arithmetic average of 3rd grade preservice teacher is 3.75, while the arithmetic average of 4th grade students is 3.68. In the last category, Educational Applications, the arithmetic average of the 3rd grade preservice teacher is 3.95, while the arithmetic average of the 4th grade students is 3.88. When the arithmetic averages are examined, the category in which preservice teacher have the highest arithmetic average in both grade levels is the 'Educational Applications' category. The category with the lowest arithmetic mean is the 'Method' category at both grade levels.

Conclusion and Discussion

The fact that prospective science teachers at the specified grade levels exhibit attitudes towards the reconceptualized family resemblance approach to the nature of science that are above average and positive indicates their positive disposition towards teaching science as well. Muğaloğlu (2006) emphasized that as the scientific skills and positive attitudes of prospective teachers towards teaching science improve their perspectives on the nature of science also become more favorable. Prospective science teachers' participation in laboratory courses has been effective in shaping their positive attitudes towards the approach.

In Bilen's study in 2003, it was noted that prospective teachers who engaged in laboratory studies developed a positive attitude towards the scientific process by working like scientists in identifying existing problems, formulating methods for problem-oriented research, and drawing conclusions akin to scientists. Laboratory studies are associated with the scientific practices category of the family resemblance approach. Moreover, the lack of statistically significant difference between the grade levels of prospective science teachers suggests that there is no variation in the course content supporting the reconceptualized family resemblance approach to the nature of science between third-year and fourth-year students. This could imply that teaching does not progress qualitatively and cumulatively as students advance in their studies. Although Okan and Kaya (2023) emphasized that the family resemblance approach can be taught at all grade levels, they underscored the necessity for a cumulative progression in this teaching.

Another reason for the absence of statistically significant differences in the attitudes of prospective science teachers towards the family resemblance approach at different grade levels could be the lack of practical application in classroom instruction. Deficiencies in practical applications may include insufficient classroom discussions, unequal emphasis on each criterion of family resemblance, a lack of collaborative learning, and prospective teachers not taking an active role in the process. These aspects are associated with the Scientific Practices category of the family resemblance approach.

In reviewing the literature, Kaya and Erduran's (2019) study demonstrated that implementing workshops and practical applications in teaching the family resemblance approach led to significant improvement, as evaluated before and after the application. This indicates that practical applications yield more successful results in teaching family resemblance. Similarly, Cullinane and Erduran's (2022) study, which included practical applications, showed an increase in prospective teachers' knowledge levels regarding the family resemblance approach to the nature of science after the application. These studies underscore the effectiveness of practical applications in teaching the family resemblance approach, aligned with the Scientific Practices category. To effectively teach the family resemblance approach to the nature of science, criteria for both the nature of science and the family resemblance approach should be directly introduced to prospective teachers, ensuring their familiarity with the criteria and concepts.

Furthermore, given the lack of statistically significant differences in the attitudes of prospective teachers at different grade levels within this study, differentiation in course content should be considered for both grade levels. Additionally, increasing the use of laboratories in teaching the nature of science based on this approach and encouraging prospective teachers to actively engage in research processes akin to scientists through various activities suitable for the nature of science are crucial steps.

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Received: June 28, 2024
Revised: July 07, 2024
Accepted: July 16, 2024

ORIGINAL ARTICLE

A Practical Exploration of Teacher Training for Child Reading Education in China: A Case Study of Qinjinmuyu's "Reading Teacher Professional Competence Certification" Program

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***Abstract**: Recent decades have witnessed growing attention to child reading education, but research on reading teacher training remains scarce, constituting an impediment to the further advancement of reading instruction. This study seeks to explore the paths to improving reading teachers' professional competence via structured training, using Qinjinmuyu's "Reading Teacher Professional Competence Certification" program as an example. Based on Qinjinmuyu's reading teacher professional competence framework, the program developed a training pattern with the four major procedures: reading training, reading instruction knowledge training, reading instruction practice, and assessment. The program's effects were also examined through questionnaires and interviews. The results reveal that the teachers who successfully completed the training course made significant progress in their knowledge of child literacy, reading curriculum design, and reading instruction techniques.*

Science Insights Education Frontiers 2024; 25(2):4163-4181
DOI: 10.15354/sief.24.or672

How to Cite: Yuan, M., & Xu, D. (2024). A practical exploration of teacher training for child reading education in China: A case study of Qinjinmuyu's "Reading Teacher Professional Competence Certification" program. Science Insights Education Frontiers, 25(2):4163-4181.

***Keywords**: Child Reading, Reading Teacher, Reading Teacher Training, Qinjinmuyu*

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***Conflict of Interests**: None*

***Funding**: No funding sources declared.*

***AI Declaration**: The authors affirm that artificial intelligence did not contribute to the process of preparing the work.*

Introduction

READING plays a crucial role in enhancing an individual's comprehension of the world, and it is considered a fundamental skill for everyone. Cognitive neuroscience research reveals a close relationship between a child's reading acquisition and their language proficiency, cognitive, and emotional abilities (Li et al., 2024). Early reading experiences are the bedrock of the child's reading competence development, crucial for their becoming lifelong learners (Zhou, 2005). China has increasingly emphasized the significance of child reading education in the 21st century as its society raises the overall standards of education. "Opinions on Promoting National Reading," released by the Chinese government in October 2020, advocates popularizing pre-primary reading education in line with the cognitive development of preschool children to help nurture their interest in reading and cultivate their reading habits (Zhong, 2020). In March 2023, the Ministry of Education and seven other departments jointly issued "The Action Plan for Promoting Reading in Chinese Adolescents and Children," which laid out systematic actions for advancing reading education among the young population. The action plan elucidates the relationship between the reading behavior of students and education outcomes and poses new requirements for school reading instruction (Ministry of Education of China, 2023).

The enhanced awareness of the value of reading calls for higher standards of child reading education. The Chinese government placed a heavier emphasis on reading education training for Chinese language teachers, as formal schooling is primarily responsible for child reading education in China. The aforementioned action plan particularly stresses the necessity of strengthening reading instruction training in Chinese language teachers and mandates including this training in the "National Teacher Training Program" as well as the regional teacher education and training systems (Ministry of Education of China, 2023). The National Smart Education Platform of China also launched the "Teacher Reading Instruction Competence Development" course. Although moves like these have significantly raised the quality of reading education, current school education in China is still examination-focused (Xu, 2023), which is unfavorable for the development of beneficial reading habits in children. Outside the schools, public cultural institutions, such as libraries, serve as the primary actors in child reading popularization (Tang, 2024), whose services supplement the school-based reading education. Yet, some researchers noted that institutions like the library may render their reading promotion activity entertaining rather than academic in a bid to engage more participants (Feng, 2024). In this context, reading teacher education and their professional development have aroused considerable interest in the Chinese education world. Certain courses on reading instruction competence enhancement have been created, such as the child reading instruction course offered by the National Library of China. Still, professional reading teacher training in China is in its infancy, and research in this area is scarce. Qinjinmuyu (hereinafter referred to as QJMY, meaning "fostering children's love of reading in Chinese"), a reading research institution founded in 2000, has been dedicated to developing a structured reading teacher training program to contribute to the pool of highly qualified and professional reading teachers. QJMY, in collaboration with South China Normal University's Education Department, launched in 2020 the "Reading Teacher Professional Competence Certification" program, targeting teachers from primary schools, picture book reading centers, and other reading centers. This article is a case study of QJMY's "Reading Teacher Professional Competence Certification" program, with the following research questions:

Q 1: What are the core competencies that qualify a professional reading teacher?

Q 2: What are the basic procedures of a professional reading teacher training program?

Q 3: What are the practical outcomes of QJMY's training program?

Literature Review

The Essential Qualities of a Professional Reading Teacher

Children's reading ability is not innate but is acquired under the direction of adults (Zhou, 2005). The teacher's professional expertise and competencies have a significant impact on the child's reading ability development (Li & Dong, 2004; Taylor et al., 2010; Porter et al., 2024). Hence, it is necessary to identify the basic qualities underlying the professionalism of a reading teacher (Ye, 1998).

Many researchers observed that a qualified reading teacher must have basic knowledge about behavioral, cognitive, and educational science; language and literature knowledge; knowledge about reading evaluation and parental reading involvement; and knowledge about child reading leveling (Strickland et al., 2002; Zhou, 2005). Based on a review of 58 prior studies, Chen (2021) tried to categorize reading instruction-related qualities of a Chinese language teacher in five dimensions: (i) notions of reading education, e.g., the purposes of teaching objective setting and the awareness of fostering the students' reading competence and habits; (ii) reading teaching design, including introduction of teaching materials, teaching methods, multimedia usage, etc; (iii) teaching enactment, e.g., teaching

Table 1. Overarching Standards for the Preparation of Literacy Professionals 2017.

Standard Title	Overarching Standard
1: Foundational Knowledge	Candidates demonstrate knowledge of the theoretical, historical, and evidence-based foundations of literacy and language and the ways in which they interrelate and the role of literacy professionals in schools.
2: Curriculum and Instruction	Candidates use foundational knowledge to critique and implement literacy curricula to meet the needs of all learners and to design, implement, and evaluate evidence-based literacy instruction for all learners.
3: Assessment and Evaluation	Candidates understand, select, and use valid, reliable, fair, and appropriate assessment tools to screen, diagnose, and measure student literacy achievement; inform instruction and evaluate interventions; participate in professional learning experiences; explain assessment results and advocate for appropriate literacy practices to relevant stakeholders.
4: Diversity and Equity	Candidates demonstrate knowledge of research, relevant theories, pedagogies, and essential concepts of diversity and equity; demonstrate and provide opportunities for understanding all forms of diversity as central to students' identities; create classrooms and schools that are inclusive and affirming; advocate for equity at school, district, and community levels.
5: Learners and the Literacy Environment	Candidates meet the developmental needs of all learners and collaborate with school personnel to use a variety of print and digital materials to engage and motivate all learners; integrate digital technologies in appropriate, safe, and effective ways; foster a positive climate that supports a literacy-rich learning environment.
6: Professional Learning and Leadership	Candidates recognize the importance of, participate in, and facilitate ongoing professional learning as part of career-long leadership roles and responsibilities.
7: Practicum/Clinical Experiences (for specialized literacy professionals only)	Candidates apply theory and best practice in multiple supervised practicum/clinical experiences.

environment creation and the use of tactics for posing questions; (iv) professional expertise, including reading competence and knowledge reservoirs; (v) self-development, including updating reading teaching notions and methods, enhancing professional levels, and constantly reflecting on teaching outcomes.

In addition to research efforts in academia, governmental and non-governmental organizations have worked to establish standards for professional reading teachers. *Standards for the Preparation of Literacy Professionals 2017* (**Table 1**), advanced by the International Literacy Association (2018), specify reading teachers' essential expertise and competences in seven dimensions: foundational knowledge; curriculum and instruction; assessment and evaluation; diversity and equity; learners and the literacy environment; professional learning and leadership; and practicum/clinical experiences (for specialized literacy professionals only).

In its *Literacy: Reading-Language Arts Standards*, the U.S. National Board for Professional Teaching Standards (NBPTS) (2012) laid out five core propositions as the foundation of all standards and assessments: (1) Teachers are committed to students and their learning; (2) teachers know the subjects they teach and how to teach these subjects to students; (3) teachers are responsible for managing and monitoring student learning; (4) teachers think systematically about their practice and learn from their experience; (5) teachers are members of learning communities. According to the standards, an accomplished teacher, in implementing reading instruction, should be able to make well-planned teaching arrangements, imparting to students effective reading skills; to provide students with suitable reading materials in accordance with their reading interests and levels; to improve students' comprehension of reading materials via multiple tactics; to encourage critical evaluation of reading materials in students; and to administer effective diagnosis to student reading comprehension and outcomes.

The Guidelines for Pre-primary, Primary and Secondary Teacher Training Courses (Chinese Language Teaching in Compulsory Education), released by the Ministry of Education of China (2017), provides the objectives and content of reading instruction training for Chinese language teachers, emphasizing that reading training courses should focus on fostering five key competences in the teachers including delivering textbook-based reading instruction; establishing legitimate teaching objectives and selecting pertinent reading materials; devising teaching activities and resources that are consistent with teaching objectives; adjusting teaching to the student's learning circumstances; and directing the whole-book reading of the students.

Existing Training Patterns for Reading Teachers

Researchers and educational organizations have also explored the specific measures for enhancing the language teachers' reading instruction competence. For instance, the American Board for Certification of Teacher Excellence (ABCTE) establishes tailored learning plans for reading teacher certificate applicants and delegates professional reading coaches to assist with their mastery of scientific reading instruction skills and strategies regarding teaching plan development, reading instruction execution, and in-class reading activity organization. The applicants must complete all compulsory courses within one year and take exams on reading ability and reading education knowledge, which cover aspects like reading fluency, vocabulary, comprehension of literary and non-fictional texts, differentiated instruction, phonemic awareness, phonetic teaching, and pedagogical theories in the traditional paper-and-pencil form. If the applicant passes both exams, they are granted a reading teacher certificate (Hong, 2010).

In China, the Guidelines for Pre-primary, Primary, and Secondary Teacher Training Courses (Chinese Language Teaching in Compulsory Education) give detailed specifications for reading training courses for Chinese language teachers. First, the Guidelines propose a range of training themes corresponding to the aforementioned five key competences (**Table 2**). Second, the Guidelines recommend 54-hour theoretical courses and 111-hour practical courses for Chinese language teachers at various education

Table 2. Guidelines for Pre-primary, Primary and Secondary Teacher Training Courses (Chinese Language Teaching in Compulsory Education): Reading Instruction Training Themes.

Key Competences	Training Themes
Delivering textbook-based reading instruction	Notions of reading and reading approaches
	Pinpointing highlights of the texts
	Predicting and analyzing difficulties with student reading of the textbook
	Educative roles of the textbook
	Extensive reading surrounding excerpts from classic works
Establishing legitimate teaching objectives and selecting pertinent teaching materials	Perceptions of reading education
	Establishing reading education objectives
	Reading instruction methods
	Reading material selection
	Reorganization of textbook content
Devising teaching activities and resources that are consistent with teaching objectives	Conformity of before-class and after-class reading activities with in-class teaching
	Reading instruction procedures
	Designing teaching activities surrounding the highlights of the textbook
	Developing teaching resources based on the needs of reading instruction
Adjusting teaching to the student's learning circumstances	Static teaching plans and dynamic teaching enactment
Directing whole-book reading of the students	Teaching design and enactment of whole-book reading

levels. The theoretical courses educate the teachers on theoretical knowledge related to reading and reading education; amid the practical courses, they practice reading teaching skills and strategies by means of group lesson preparation, case analysis, experience sharing, and more. It should be noted that the trainee does not have to attend all these courses. Before the onset of the training, the trainee receives a reading instruction competence assessment and chooses the courses that best support their professional development based on the assessment results and the guidelines' recommendations. Third, the guidelines also require the training institutions to adopt the multi-dimensional evaluation method to include qualitative and quantitative assessments, phased and summative evaluation, and self-evaluation and peer mutual evaluation to realize a comprehensive appraisal of the training effects.

On top of these institutional reading teacher training schemes, we also looked into the practices of those popular training programs aimed at preparing highly qualified reading teachers. Researchers summarized 15 crucial components of reading teacher training based on literature reviews and practical studies (Cruickshank & Metcalf, 1990; Hoffman & Pearson, 2000):

- Establishing explicit training objectives and delivering them to the trainees.

- Ensuring that the trainees understand the targeted levels of reading instruction competence.
- Documenting the trainee's pre-training levels of reading instruction competence.
- Providing basic rules at the initial stage of training.
- Adapting the design of the training course to the trainees' existing competencies at the early stage of training.
- Assisting the trainee in developing a fundamental conception of the skills to be learned at the initial stage of training.
- Demonstrating to the trainee how to apply relevant skills at the initial stage of training.
- Giving the trainees the opportunities for discussion and representation.
- Providing intermittent but sufficient opportunities for practicing the skills after the trainee has developed a basic understanding of them.
- Ensuring that the trainee receives feedback following the practice.
- Providing more frequent feedback at the early stage of training.
- Administering intervention on the training's improper performance.
- Giving delayed feedback after the training has completed the initial phase of training.
- Facilitating the transfer of training outcomes by increasing the similarity between the training and actual teaching scenarios and providing a diverse range of practices, as well as adopting delayed feedback, prompting reflections, and giving intermittent assessments.
- Assisting the trainee to reinforce the acquired skills in the actual teaching setting.

QJMY's "Reading Teacher Professional Competence Certification" Program

QJMY's Reading Teacher Professional Competence Framework

Drawing on established standards for reading instruction competence, theories of children's literature and psychology, traditional Chinese reading education practices, and China's education policies and regulations, QJMY developed a reading teacher professional competence framework in the context of Chinese education. This framework lays out the following requirements for a qualified reading teacher: (1) Emotionally, they shall have positive attitudes towards reading and child reading education. (2) They have a legitimate outlook on child education and views of children's rights and developmental characteristics, which, in turn, impact their practices in reading education. (3) They are proficient readers themselves with excellent reading comprehension and critical thinking. (4) They have professional expertise in children's literature as well as comprehensive knowledge in multiple disciplines, including sciences, social sciences, and humanities. (5) They have multiple reading teaching techniques, including creating engaging reading environments, organizing meaningful readings, planning an effective lesson design, and harnessing educational technology to assist with reading instruction. (6) They have excellent expression skills and are capable of creating an interesting and enjoyable atmosphere to engage their students.

The Program's Training Procedures

Underlying QJMY's "Reading Teacher Professional Competence Certification" program are three principles: (i) The design of training content is based on the said reading teacher professional competence framework; (ii) The effects of the training course are measured by the achievements of the trainee; (iii) The training paths are progressive, assisting the ongoing development of the trainee. The program offers elementary-, intermediate-, and advanced-level certificate courses to accommodate the individually different needs of the applicants (the advanced-level course is in development). Each course consists of four basic procedures, including reading training, reading education knowledge training, reading instruction practice, and assessment.

Reading Training

The teacher's reading behavior has a significant impact on their reading instruction. Teachers who read for more than 30 minutes a day are more capable of using appropriate strategies in reading teaching compared to those without the regular reading habit (Mckool & Gespass, 2009). Also, reading itself is an effective device for improving the reading teacher's professional competence (Li, 2022; Zheng, 2024). Thus, a favorable reading habit and high reading proficiency are the bedrock of the reading teacher's instructional practices. The teacher trainees receive two kinds of reading training from the program.

Specialist Books Reading: To be a qualified reading instructor, the reading teacher needs to develop knowledge in education, child psychology, literature, etc. For elementary-level certificate applicants, the program stipulates compulsory reads such as Reading Handbook, Creating Child

Reading Environments, and Seeds of Happiness. The must-read list for intermediate-level certificate applicants includes but is not limited to Children's Positions, The Teacher's Spiritual Power, Introduction to Children's Literature, and Children, Reading and Discussion. The intermediate-level reading list, compared to the elementary-level one, is of greater theoretical depth and width, spanning knowledge about pedagogy, child education, reading instruction theories, literary theories, etc. The program also encourages the teacher trainees to do more extensive reading to include works of renowned educators, such as Rousseau, Montessori, Sukhomlinski, Dewey, Xingzhi Tao, and Heqin Chen, in their personal reading lists.

Study of Children's Literature: Successful reading teaching design is contingent on the teacher's in-depth understanding of the reading material, warranting their extensive reading of children's books, especially children's literature. A qualified reading teacher is typically adept at tapping into "topics of greatness" in the work and introduces them to their students in a bid to inspire the latter's contemplation. These "topics of greatness" will strike a chord with the young reader and nurture their emotional and spiritual power (Xu, 2023). Teachers who read children's books extensively have the ability to recommend the appropriate materials to their students in accordance with their preferences and reading levels, reaching effective communication with them via enjoyable reads. The program provides a must-read list of 40 children's books for the elementary-level certificate applicants, including 20 picture books and 20 non-picture books, and a must-read list of 50 children's books for the intermediate-level applicants, including 10 picture books and 40 non-picture books, such as *The Scarecrow, Andersen's Fairy Tales, Grimm's Fairy Tales, Lan and Hui Born in the Year of Rat, Ancient Chinese Mythology, The Thatched Cottage, and Memories in Old Beijing*.

Reading Instruction Knowledge Training

The teachers who equate reading ability to reading instruction competence are likely to impose their own reading experience on their students, compromising their quality of reading instruction (Li, 2011). To increase the teacher's ability to adapt their reading experience to reading instruction practices, the program created online reading instruction knowledge training courses for different levels of applicants. For example, the course for the elementary-level applicants includes the following seven modules: reading education notions and literature literacy, child recitation training, picture-book reading education, whole-book reading education, thematic reading education, in-class reading practices, and specialist lectures (**Table 3**),

Table 3. QJMY's "Reading Teacher Professional Competence Certification": The Reading Instruction Knowledge Training Modules (Elementary-Level).

Modules (for schoolteachers)	**Modules (for teachers at non-school reading training institutions)**
(1) Reading education notions and literature literacy	(1) Reading education notions and literature literacy
(2) Child recitation training	(2) Child recitation training
(3) Picture-book reading education	(3) Picture-book reading education and children's readings
(4) Whole book reading education	(4) Whole book reading education and children's readings
(5) Thematic reading education (elective)	(5) Thematic reading education and children's readings (elective)
(6) In-class reading practices (elective)	(6) Exemplary cases of reading training institutions (elective)
(7) Specialist lectures	(7) Specialist lectures

Table 4. QJMY's "Reading Teacher Professional Competence Certification": The Reading Instruction Knowledge Training Modules (Intermediate-Level)

Module 1. Reading education notions and literature literacy	(1) Reading education notions
	(2) Literature literacy
Module 2. Appreciation and instruction	(1) Appreciation and instruction of poetry
	(2) Appreciation and instruction of picture books
	(3) Whole-book reading instruction
	(4) Appreciation and instruction of children's stories
	(5) Appreciation and instruction of fairy tales
	(6) Appreciation and instruction of novels
	(7) Appreciation and instruction of myths and folk stories
	(8) Appreciation and instruction of essays
	(9) Appreciation and instruction of non-fictional works
Module 3. Enactment and evaluation	(1) Creation of reading environments
	(2) Organization of in-class readings
	(3) Planning and enactment of reading-related events
	(4) Evaluation of child reading competence

aiming to facilitate the implementation of a child-centered reading education curriculum.

The training course for the intermediate-level applicants is more focused on the teacher's appreciation and instruction of various genres of writing, with three chief modules: reading education notions and literature literacy; appreciation and instruction; and enactment and evaluation (elective) (**Table 4**). Module one is to further improve the teachers' theoretical knowledge of reading education and literature literacy. Module two aims to enhance the teacher's appreciation and instruction of various reading materials. Module three includes training on the construction of positive reading environments, organization of in-class readings, hosting of reading-related events, and evaluation of student reading competence.

Reading Instruction Practice

According to Clark et al. (2013), the teacher's mastery of reading education knowledge does not necessarily mean they can successfully apply it in the actual teaching scenario. Morris (2015) analyzed the reasons for unsuccessful reading instruction and defined practical training as the paramount step in training professional reading teachers. Through targeted and deliberately repeated practical exercises in reading instruction, the teacher can better grasp the essentials of the teaching of varied reading materials. Hence, the program administers practical training to the applicants who have completed the sessions of reading training and reading instruction knowledge training. The practical training takes two forms. One is based on the online and offline thematic workshops, where the trainee conducts simulation classroom instruction under the direction of an experienced mentor, who gives instant feedback, helping the former to continuously modify their teaching behavior. The other is based on the footage of the trainees' in-class reading instruction, which records their classroom implementation processes, interactions with students, and design of questions and is used by the trainers as evidence for their judgment of the trainees' performance.

Assessment

QJMY's training program gives a comprehensive evaluation of the reading education competence of the teacher by combining the formative assessment during the training process and the summative assessment at the end of the training session. The trainee earns credits in completing the preceding three sessions of reading training, reading instruction knowledge training, and reading instruction practice, which ensures a multi-dimensional evaluation of their training outcomes. Specifically, in the reading training session, the trainee takes the reading comprehension test after finishing reading designated books to assess their reading competence. In the reading instruction knowledge training session, the trainee needs to spend prescribed hours watching recorded lectures and subsequently answer questions for each module; the test results are generated automatically on the platform. Furthermore, the trainee is required to submit a teaching design and videos of trial instruction pertaining to the training content as outcomes of the practical training session. Only after reaching the criteria of all three sessions can the trainee sit in the final assessment. In addition, to obtain an intermediate-level certificate, the trainee needs to participate in regular standardized tests, which include objective questions and open-ended questions, aside from submitting teaching designs and videos of classroom instruction. This more careful assessment is to verify that the applicant is qualified for the higher-rank certificate. The program's assessment system places equal weight on the teacher's mastery of theoretical knowledge of reading education and their ability to transfer the knowledge to practical instruction.

Practical Outcomes of QJMY's "Reading Teacher Professional Competence Certification" Program

To investigate the effects of the training program on the teachers' gains in reading instruction competence and their teaching performance, QJMY conducted a random questionnaire survey of prior trainees, with a total of 600 questionnaires being distributed and 580 (96.7%) of them being retrieved. All retrieved questionnaires were valid. Furthermore, QJMY picked 30 teachers from the respondents to have one-on-one interviews with them. We numbered these interviewed teachers as T1-T30 for the subsequent analysis and discussion.

Changes in the Teachers' Knowledge of Reading Education after Training

The questionnaire contains certain questions aimed at evaluating the change in the teachers' knowledge of reading education. According to the survey results, 88.1% of the respondents reported enhanced understanding of the significance of reading education; 87.59% of them learned more about children's books, especially children's literature; 82.07% said the training aided them in developing more effective reading teaching methods and techniques; 69.14% learned to organize reading-related events of diverse forms. Also, the program had significant impacts on the teachers' perceptions of child reading education. Among them, 90.86% placed a greater value on the reading of children's literature in their students, 80.17% developed the conception of leveled reading, and 79.31% improved their grasp of the essentials of reading instruction after receiving the training.

In the one-on-one interviews, the teachers were asked the question, "What changes does the training program make to your reading instruction?" The following are some examples of their answers:

T7: As the training program recommends, I now ask my students to spend 10 minutes on Everyday Recitation per day and a scheduled session to whole book reading every week. I can use different teaching methods for various reading materials and become more adept at provoking students' interest in reading and engaging them in deep reading.

T9: I used to simply recommend some books for the students' voluntary reading without proposing explicit reading targets. Now, my *students read Everyday Recitation every morning and have one reading lesson in the school library every Wednesday.*

T24: The training courses taught me how to pick books for the varied needs of the students and made me more proficient in reading instruction.

T28: With the training program. I learn more specialist theories on reading education and become more professional in reading course design. Also, I can consult QJMY's child reading education paradigm in developing a structured, scientific reading instruction curriculum for my students.

T29: The training program provided me with the opportunity to develop more scientific concepts of child reading education and to systematically study the methods and techniques for reading instruction, including picture-book and whole-book reading teaching as well as the instruction of children's poems and rhymes.

The teachers' statements indicate that the training program had positive impacts on their reading instruction knowledge, making their reading teaching more professional and effective.

Improvements in Reading Education Practices

Upgraded Reading Environments

An ideal reading environment is an important factor in piquing the students' interest in reading and fostering their reading habits. According to Chambers (2007), the selection of books is the starting point of successful reading activity. The student's reading journey begins with ample reserves of books, and more importantly, they are easy to access and are displayed in a way that best provokes the child's love of reading. This questionnaire survey evaluates the teacher trainee's effort to develop a good reading environment by the class's collection of books and the teacher's guidance on the choice of books. As per the survey results, the majority of the teachers set up a bookcase in the classroom after completing the training. More than half (60.35%) of them reported a collection of over 100 books in their classrooms, among whom 33.97% claimed their classes owned more than 300 books each. This suggests that the training program is effective in boosting the teacher's awareness of the value of book resources for reading competence development of the students.

As to the students' reading lists, 71.38% of the teachers surveyed used QJMY's leveled reading list in recommending suitable reading materials to their students, while 19.31% relied on their personal experiences in doing so. Only 3.97% expressed satisfaction with the unified textbook's proposed reading list. These figures show that the majority of these teachers knew how to guide their students in book selection, drawing on their knowledge about books or QJMY's leveled reading list. Only a small percentage of these teachers lacked this skill. The disparity may be the result of the variation in the reading volume among them, as the teachers who read more extensively know better what books best suit the needs of their students (Mckool & Gespass, 2009).

Bolstered Reading Education Curriculum and Extracurricular Reading Activity

According to the questionnaire survey results, the teachers could develop a better-structured curriculum for their reading instruction after receiving the training, with 81.38% of them including whole-book reading teaching, 66.21% of them picture-book reading instruction, 54.48% of them recitation teaching, and 37.24% of them thematic reading instruction in the reading curriculum. The survey results are supported by the teachers' statements in the interviews, which show that recitation, picture-book reading, and whole-book reading were the primary components of the reading class. The students typically recited in the morning reading session, did picture-book and whole-book reading in the noon reading session, and had one or two scheduled reading classes every week.

T5: My students and I co-read Everyday Recitation in the morning reading session. The students do voluntary reading during a noon break and co-read a picture book in a Wednesday class. We co-read a book every two months.

T29: We concentrate the reading instruction in one session scheduled by the school, focusing on whole-book reading while also paying attention to the teaching of picture books and children's poems. The whole-book reading class consists of the introductory lesson, reading comprehension enhancement lesson, and free exchanges between the students. The students often finish reading one book within a month. They spend the morning reading session and the first two minutes of each Chinese language class on recitation training. In addition, an online reading task completion checking device is deployed to track and record the student's reading behavior. Also, we encourage parent-child co-reading.

The questionnaire also investigates the effect of the training program on the teacher's direction of student extensive reading by posing questions about time allotment to extensive reading and the teacher's efforts to encourage voluntary reading in students. According to the survey results, the program has significantly enhanced the teacher's understanding of the significance of extensive reading. Among the teachers surveyed, 40%, 28%, and 16% of them allowed 16-30, over 30, and 10-15 minutes for student in-class extensive reading every day, respectively. Only 8% did not allot in-class time to student voluntary reading. The overwhelming majority of teachers at off-campus reading centers chose to assign extensive reading homework to the young readers, who could borrow books from the reading center; only 8% of them had the children do in-class extensive reading. Also, the survey results show the program is effective in motivating the teachers to organize colorful extracurricular reading events to boost extensive reading in the students, with 32% of the surveyed teachers staging 1-2 reading events (e.g., the storytelling competition, recitation performance, book recommendation, etc.) every semester, 28% of them organizing over 2 reading events per week, and 24% of them staging 1-2 reading events every month. Only 4% of them failed to organize any extracurricular reading events for their students. In addition, the increased reading volumes of the students are evidence of the improved reading education competence of the teachers surveyed. 52%, 28%, and 20% of them reported that their students could voluntarily read 6-10, 11-20, and over 20 books every year, respectively. This shows that most students have basically developed the habit of autonomous reading, but their reading volumes are pending further elevation.

Interviews with the 30 teachers find that common devices for instigating extensive reading in the students include creating incentive mechanisms, constructing reading outcome display platforms, encouraging parental involvement, and organizing diverse reading events. The self-reports of T11, T14, and T21 give more details in this regard.

T11: I created a reading performance recording area, dubbed "Bookworms," on the blackboard, where every student has their personal post-it section to showcase the names of the books they have read. The student is rewarded a butterfly-shaped sticker for every 10 books read. The number of the stickers collected is a criterion for the selection of "reading stars" at the end of the academic year.

T14: I believe that student reading competence development is an ongoing process. I often read a story to my students and have them write down their comments; those who do a good job will be praised. Also, the students can read aloud in turns in their study group and exchange ideas on the story. Commenting on the writing they have read is an effective way of instigating their contemplation. Furthermore, I have tried to act as a role model for my students by always having a literary work or a book about educational theories with me, which I can read whenever time is available.

T21: My students have half an hour at noon for voluntary reading. We have two reading festivals surrounding Confucius' birthday on September 28th and the April 23rd World Book Day, during which there are a variety of reading events, such as the Chinese Poem Contest, recitation performance of classic works, the "flea market" selling books, etc. This year, we organized the "Reads Recommendation" in collaboration with the school library, in which the students created recommendation cards and videos for *excellent reads. Reading events like these have successfully stimulated the students' interest in extensive reading.*

Conclusion

This study is a practical exploration of teacher training for child reading education in China, using QJMY's "Reading Teacher Professional Competence Certification" program as an example. With its structured training scheme, the program has showcased its effectiveness in enhancing the reading education knowledge, reading curriculum design ability, and reading instruction techniques of Chinese-language teachers. Nevertheless, limitations of the program should also be acknowledged. For instance, it lacks consideration of the differences in the requirements for reading teacher training between various regions and schools. The practical training session of the program should include more analyses of diverse, exemplary teaching cases and more on-site reading instruction training to heighten the teacher trainees' ability to adapt to differential reading education contexts.

We suggest that future developers of the reading teacher certificate course or training program pay more attention to the following issues. First off, more research on tailored reading instruction training courses is warranted to serve the individually different needs of the teacher trainees to enhance training outcomes. Furthermore, it is necessary to introduce global perspectives on and experiences in reading teacher education into the local training program to create more professional training platforms for Chinese reading teachers.

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Received: November 03, 2024
Revised: November 24, 2024
Accepted: December 04, 2024

REVIEW

Data-Driven Instructional Decision-Making Models: A Literature Review

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***Abstract**: In recent years, the application of big data technology in education has attracted wide attention in academia. How to leverage big data to reach scientific instructional decision-making has become a topical issue. Based on a literature review of relevant studies, this article gives an overview of the evolution of data-driven instructional decision-making models in order to provide educators with a broad perspective on this subject. It also makes a comparative analysis of certain representative models, aiming to provide teachers with valuable insights for facilitating their application of big data technology to teaching decision-making.*

Science Insights Education Frontiers 2024; 25(2):4183-4198
DOI: 10.15354/sief.24.re431

How to Cite: Zhao, S., & Hu, Y. (2024). Data-driven instructional decision-making models: A literature review. Science Insights Education Frontiers, 25(2):4183-4198.

***Keywords**: Big Data, Instructional Decision Making, Data-Driven Decision Making, Data-Based Decision Making, Data-Informed Decision Making*

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***Conflict of Interests**: None*

***Funding**: No funding sources declared.*

***AI Declaration**: The authors affirm that artificial intelligence did not contribute to the process of preparing the work.*

Introduction

AMID THE ADVANCEMENT of information technology and the proliferation of digital data, human society has entered the era of big data. The ongoing waves of big data are fundamentally transforming all facets of society (United Nations Global Pulse, 2012; Zou & Yin, 2018). In the field of education, big data technology is bound to make a difference to the teacher's instructional decision-making. Instructional decision-making is a process in which the teacher explores, selects, and evaluates the teaching implementation schemes for the purpose of successfully reaching specific educational goals (Guan et al., 2019). It is the intermediate link between the educational ideas and teaching practices of the teacher (Borko et al., 2008). Traditional instructional decisions often rely on the teachers' personal experiences, which can lead to issues such as inadequate information collection during the preparation stage, an overreliance on individual experience in decision-making, and a lack of feedback during decision implementation (Li et al., 2023). These issues can compromise the quality and effectiveness of teaching decisions. The application of big data technology in education has the potential to ensure a more solid information foundation for evidence-based instructional decisions (Zhang, 2017) and to make the teacher more focused on the learning process and cognitive experiences of the individuals rather than those of a collective group (Zou & Yin, 2018; Li & Xia, 2020). Benefits like these have prompted many empirical studies on questions like "Is data-driven instructional decision-making really effective?" "What are its positive effects?" and "How significant are these effects?"

With the increase in empirical research on big data-driven instructional decision-making, a few meta-analytical studies have emerged in this area. Using meta-analytic techniques, Li et al. (2023) examined the impact of data-driven instructional decision-making on student learning outcomes based on relevant empirical studies published between 2003 and 2022. Their research findings show that data-driven instructional decisions could significantly promote students' learning outcomes by facilitating their knowledge retention and transfer, supporting their problem solving and engagement in learning, and elevating their motivation levels as well as learning satisfaction. On the basis of existing meta-analytic studies, Liu et al. (2022) used the method of umbrella review to comprehensively analyze the impacts of data-driven instructional decision-making from the standpoints of impact scope, impact cycle, and intervention measures. The study emphasizes the necessity of further exploring specific procedures of the decision-making process to optimize the effects of data-driven instructional decisions and notes that a data-driven decision-making model can provide actionable guidelines for decision-making practices of the teacher.

Currently, despite the many big data-driven instructional decision-making models advanced by researchers, systematic analyses of these models are relatively scarce. This study gives an overview of the evolution of data-driven instructional decision-making models and makes a comparative analysis of six representative big data-driven decision-making models with the intent to provide educators with valuable implications for teaching improvement.

Review of Relevant Concepts

The teacher's instructional decision-making is a process of judgment and selection in the uncertain and complex educational contexts (Zhang, 2009). It is an essential component of instruction, a key factor influencing other teaching behaviors (Ye, 2009). In the past, the teacher's educational notions, professional knowledge, and practical experience constituted reliable foundations for their instructional decisions (Borko et al., 2008; Song & Li, 2008). Yet, recent years witnessed different views among researchers. According to Feng (2020), the teacher's instructional decisions are not only impacted by their values, education levels, competences, and personality traits, but also by the accessibility of information; prior research failed to pay adequate attention to the value of information for instructional decision-making. Zou and Yin (2018) also argued that central to instructional decision-making is the teacher's mining, analysis, and evaluation of relevant data on key elements of teaching, based on which the teacher plans, implements, adjusts, and improves their teaching practices, whereas teaching decisions based on the teacher's personal experiences are insufficiently supported by objective evidence. Amid the change in the perspectives on this research area, more recent studies confirm that data-driven decision-making is effective in improving student learning outcomes (Schildkamp, 2019), which prompted increased integration of data into instructional decision-making. It has been expected that the introduction of big data can help realize more scientific, efficacious teaching decisions.

In the education world, "data-based decision making (DBDM)," "data-driven decision making (DDDM)," and "data-informed decision making (DIDM)" are the three comparable terms used to represent the process of making educational decisions using educational data. DBDM denotes the process in which teachers, school administrators, and other stakeholders gather, analyze, and interpret educational data (such as education evaluation data, classroom observation data, and research data) and use the extracted information as evidence for decision-making and for evaluating the students' academic progress and other expected educational outcomes (Feng, 2020). DDDM and DIDM, deemed similar concepts to DBDM, involve systematic processes of collecting and analyzing various types of data (e.g., teaching process data, outcomes data, and educational actor satisfaction data) on the part of administrators and teachers, which serve as justifications for their educational decisions (Ikemoto & Marsh, 2007; Feng, 2020). Some researchers contended that there are certain differences between the two, claiming that DDDM has a greater emphasis on the use of machine intelligence for data analysis, thereby reducing the involvement of human subjective judgments and personal biases in the decision-making process, while DIDM is more about leveraging data to reach meaningful conclusions and warrants high levels of data literacy in teachers (Guan et al., 2019). Despite the nuances between the three terms, they are basically identical, with the same emphasis on systematically collecting and analyzing data resources and using information gathered to improve teaching and learning. Unless otherwise specified, this article considers DBDM, DDDM, and DIDM to be synonymous.

An Overview of the Evolution of Data-Driven Instructional Decision Models

This survey sources literature from China National Knowledge Infrastructure (CNKI) and Google Scholar, using as search terms "big data," "data-based decision making," "data-driven decision making," "data-informed decision making," "instructional decision making," and "decision-making model or framework" to retrieve relevant journal articles. Our analysis is pivoted around six big data-based instructional decision-making models or frameworks from four studies in the literature.

Traditional Data-Driven Instructional Decision Models

Our purpose in discussing the traditional data-driven instructional decision models is two-fold: to give a broader picture of the development of data-driven instructional decision-making models and to facilitate the understanding of the basic components of big data-driven instructional decision-making models.

The DIKW (data, information, knowledge, and wisdom) model, advanced by Ackoff (1989), represents how data is progressively transformed into teachers' wisdom that underpins their instructional decision-making. Mandinach et al. (2006) were the earliest researchers experimenting with the data-driven instructional decision-making model, drawing on the basic ideas of the DIKW model. This model includes decision-making scenarios at three levels: school district, school, and classroom, and spans the following specific processes: collecting and organizing data; analyzing and synthesizing data and converting it into information; transforming information into decision-making knowledge

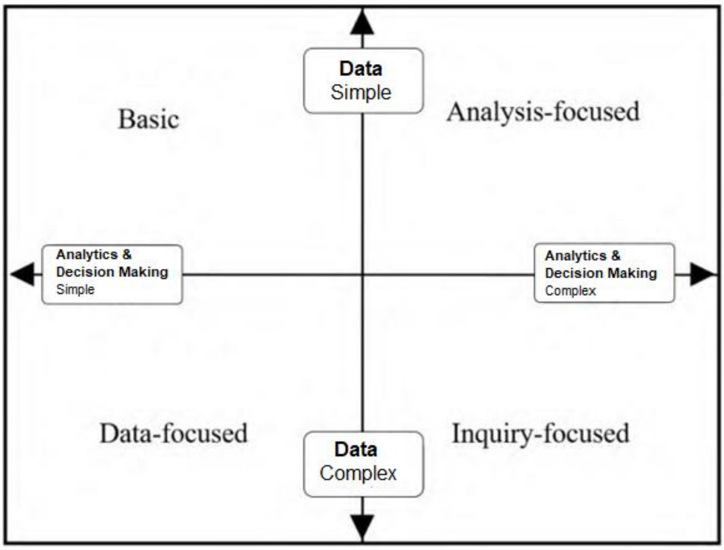

Figure 1. A Quadrant Diagram of the DDDM's Complexity.

using prescribed rules; formulating and implementing instructional decisions; and evaluating the effectiveness and impact of these decisions. Ikemoto and Marsh (2007) modified the above model by adding a quadrant diagram to represent the DDDM's complexity (**Figure 1**) to address the issue of oversimplistic description of DDDM processes. The diagram abstracted chief elements from DDDM, with the Y-axis representing the types of data and the X-axis signaling analytics and decision-making, aiming to offer guidance for the use of different types of DDDM in educational decision-makers.

Schildkamp and Poortman (2015) expanded Mandinach et al.'s model by adding the process of setting objectives for decisions and managed to create a more workable and applicable instructional decision-making model. The model specifies the following processes: (1) Pinpoint the objective of data collection as well as the types and uses of data to be collected; (2) gather data pertaining to the objective; (3) draw information from data via data mining and analytics, such as information on problems with teaching; (4) combine the teacher's professional expertise with obtained information to generate knowledge for decision-making; (5) leverage the newly generated knowledge to assist with decision-making and the implementation of decisions; (6) evaluate the effects of decision implementation. To improve the objectivity and neutrality of decision-making, Dodman et al. (2021) created the critical data-driven decision-making (CDDDM) model by combining Ikemoto and Marsh's model and Duncan-Andrade and Morrell's (2008) "cycle of critical praxis." With this model, the teacher is required to remain critical throughout the processes of data collection, data interpretation, and decision-making and encouraged to screen out institutional data (such as social network data) that can potentially instigate and maintain inequality within the school to guarantee that school decision-making is driven by fairness and justice (Dodman et al., 2021; Zhang et al., 2021).

The above review reveals that the essence of traditional DDDM is that meaningful information closely related to teaching situations is extracted from data via the teacher's analysis and processing to aid in their instructional decision-making. Common procedures of traditional DDDM include gathering data, analyzing data, establishing evidence for decision-making, and formulating and implementing decisions (Qi, 2021). Big data-driven instructional decision-making models share the same essence and procedures, but with further developments.

Big Data-Based Instructional Decision-Making

In the era of big data, the emergence of educational technology of all forms, such as the large-scale online learning platform, classroom teaching diagnosis tool, wearable learning-assisting device, and smart classroom, has resulted in an exponential increase in educational data. To address the huge volumes of educational data, data analytics is used to discern relations between various factors, diagnose teaching problems, and predict trends in student learning (Zhong & Hou, 2017), acting as a valuable instrument for the teacher's decision-making. In this context, a variety of big data-based instructional decision-making models have been developed in reaction to the increased impact of big data on teaching decisions.

To address issues with the teacher's decision-making, such as overdependence on subjective judgments, a lack of adjustment to classroom dynamics, and inadequate real-time evaluation, Zhong and Hou (2017) created a big data-based decision-making model (**Figure 2**) by introducing educational data into the process to improve the instructor's teaching design, interaction, and evaluation. With this model, the teacher gathers instructional data from the content management system (CMS), learning management system (LMS), school information system, and other data sources using technological tools. In the procedure of teaching design, the teacher analyzes the gathered data with analytics software to generate information as the groundwork for pinpointing learning objectives, deciding on teaching materials, and preparing teaching resources. In the procedure of teaching interaction, the teacher and students communicate through the information exchange platform, which records and analyzes data in real time.

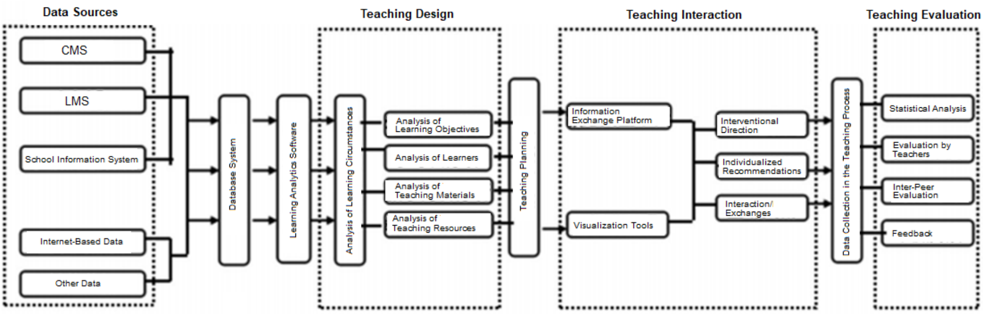

Figure 2. An Educational Data-Based Instructional Decision-Making Model.

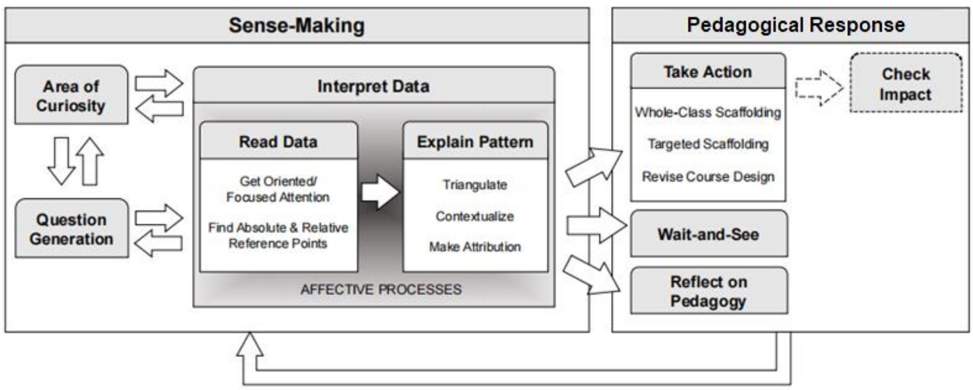

Figure 3. Wise and Jung's Situated Model of Instructional Decision Making.

Visualization tools are adopted to present the results of data analytics in a timely manner to facilitate the teacher's understanding of the students' mastery of knowledge and progress in learning as well as their provision of individualized intervention and tailored learning resources. In addition, the data gathered throughout the teaching process supports the teacher in reflecting on their own teaching behavior and evaluating the students' learning outcomes.

Guan et al. (2019) developed a data-driven instructional decision-making model targeting smart classroom environments. This model represents an evidence-focused process, including three procedures: conception of evidence, formation of evidence, and evidence-based decision-making. In the first procedure, the teacher needs to consider the correspondence between the objectives of decision-making and the data to be gathered. They must define the teaching focuses and establish and operationalize the objectives of decision-making first and subsequently select data acquisition routes and appropriate observation/measurement tools accordingly. The second procedure of evidence formation includes a few specific steps: gathering data, screening data, extracting information, generating new knowledge for problem identification, analyzing causes of problems, and directing decision-making actions. In addition, for the data generated in the smart classroom environment, the teacher can visualize learning data using intelligent tools, such as statistical analysis graphs of exercise/test results. Based on the first two procedures, the teacher can ultimately formulate the decision, implement it, and evaluate its effects in practice.

Wise and Jung (2019) investigated the experiences of five university teachers working with a learning analytics dashboard in authentic teaching settings. The findings were integrated to generate a situated model of instructional decision-making (**Figure 3**), which consists of two main parts: sense-making and pedagogical response. Data interpretation involved two distinct activities: reading data to identify noteworthy patterns and explaining their importance in the course using contextual knowledge, often along with affective reactions to data. Pedagogical responses to the analytics included whole-class scaffolding, targeted scaffolding, and revising course design, as well as two new non-action responses: adopting a wait-and-see posture and engaging in deep reflection on pedagogy.

Yan and Wang (2023) developed three DDDM models based on three different entry points to analytics, namely the platform, data, and question. Drawing on Ikemoto and Marsh's (2007) categories of decision-making, they named the three models as the analysis-focused decision-making model, the data-focused decision-making model, and the inquiry-based decision-making model. The analysis-focused decision-making model uses the platform as the entry point, which refers to the intelligent data analytics platform that can gather, process, and present data. Such a platform can lighten the burden of collecting teaching data on the teachers, but they may encounter additional difficulties in interpreting the analytic results generated by the platform. This model comprises six steps: creating a basic platform environment, defining data sources, examining data quality, identifying problems, discovering their causes, and generating solutions. The data-focused decision-making model also has six steps, namely, collecting and presenting data, analyzing strengths and gaps, establishing objectives, clarifying indicators of outcomes, selecting intervention tactics, and reflecting on practices. With this model, teachers are primarily responsible for data collection and analysis. Without the limitations of the platform, teachers can gather a wider variety of data. Regarding data analysis and decision-making, they do not need to depend heavily on specialist advice, team support, and large amounts of empirical evidence. Instead, they use ordinary descriptive analysis, correlation analysis, difference analysis, and other methods to explore patterns, trends, or relations in teaching data for developing action knowledge for teaching improvement or teaching strategy adjustment. The inquiry-based decision-making model, using the question as the entry point to analytics, warrants comparatively more complex data and actions concerning an iterative process entailing eight clearly defined steps: establishing the question, proposing hypotheses, gathering data, examining the quality of data, analyzing data, interpreting data and drawing conclusions, implementing improvement measures, and evaluating the decision.

To recap, big data-driven instructional decision-making models have certain salient advantages over traditional DDDM ones. First, with a big data-driven decision-making model, the teacher can access a greater variety of data via technological tools and make instructional decisions that benefit every student (Wu, 2019). It not only expands the scope of evidence for the teacher's decision-making but also renders personalized instruction possible. Second, big data technology has the potential to magnify the teacher's capacity to process large datasets and to reshape the decision-making process (Hu, 2024). Traditional DDDM models typically predict teaching behavior based on existing data (Zhang, 2017) or focus on how to utilize summative assessment data to improve student academic performance (Schildkamp, 2019), whereas big data technology and visualization tools enable the teacher to collect and analyze data in real-time during the teaching process and to adjust teaching strategies accordingly. Third, the traditional DDDM model requires a predetermined objective for decision-making (Schildkamp & Poortman, 2015), which actually limits the possibilities of exploring other instructional decisions. In contrast, the big data-based instructional decision-making model allows the teacher to identify latent relations in larger amounts of data, sometimes without a preset objective; the direction of their decision-making may become clearer during the process of data analysis (Zhang, 2017). This approach gives the teacher a broader perspective in decision-making but may also make the process more complicated and uncertain.

A Comparative Analysis of Representative Big Data-Driven Instructional Decision-Making Models

Table 1 encapsulates details of the six big data-based instructional decision-making models. It shows that underpinning these models are prior experiences in DDDM model construction, teachers' in-situ practices, and relevant educational theories. All the models share a basic procedure, "from gathering data, to analyzing data, establishing evidence for decision making, and formulating/implementing instructional decisions," which indicates the

Table 1. A Comparison between Big Data-Driven Instructional Decision-Making Models.

	Zhong & Hou (2017)	Guan et al. (2019)	Wise & Jung (2019)	Yan & Wang (2023)
References	Evidence-based education; basic instructional procedures	Evidence-based education; the DIKW model	Teaching experiences based on educational data	Mandinach et al.'s DDDM model; Ikemoto and Marsh's Quadrant Diagram of the DDDM's Complexity
Purposes of the model	To provide guidelines for how to apply educational data to instructional decision making.	To guide the teachers in improving instructional decision making leveraging the smart classroom environment.	To conceptualize instructors' process of data analytics and make recommendations for analytics design and implementation.	To address issues with educational data application in decision making, such as the lack of explicit objectives and procedures in data use.
Application scenarios	Ordinary classroom teaching settings	Smart classroom environments	Ordinary classroom teaching settings	Ordinary classroom teaching settings
Technological use	Leveraging technological instruments to gather and analyze structured and non-structured data and present the results	Recording student learning data, assessment data, psychological and physiological data using the smart classroom's digital terminals, interactive system, assessment system and other devices; allowing the teacher to select data analytics software for data analysis.	Designing a learning analytics dashboard to present to the teacher various information about the activity and performance of their students in a specific course, such as student access of course site and resources, video viewership information, results of online quizzes, and student survey responses.	In the analysis-focused decision-making model, the technological tools are responsible for collecting and providing data as well as presenting the results of data analytics, while the teacher is not allowed the choice of the type of data or the method of analytics. In the data-focused decision-making model, the technological tools play a supporting role in assisting the teacher in gathering necessary data; the teacher has the right to choose the type of data needed. With the inquiry-based decision-making model, the teacher needs to identify the issue with their teaching and select legitimate data mining and analytics tools accordingly.
Outcomes	A theoretical model pending practical validation	Practical experiments with this model suggest that the teacher can enhance the effectiveness of teaching design by using data generated in the smart classroom environment.	A theoretical model pending practical validation	According to the survey results, the three models were relatively highly rated in terms of usability (4.07/5), effectiveness (4.10/5), and teacher satisfaction (4.19/5) but lower regarding learnability (3.90/5) on average.

importance of the use of technological tools as well as the agency of the teachers as the decision makers. The models' purposes and application scenarios exhibit their focus on classroom-level decision-making but show disregard for school- and school district-level decision-making, which has been evidenced by the comments of those teachers who have applied these models (Yan & Wang, 2023). Some of these models lack practical validation, leading to the uncertainties of their effects. This hampers their popularization in the teaching community. Therefore, we need more experimental research to demonstrate their reliability and effectiveness.

Furthermore, Yan and Wang (2023) observed that the overgeneralization of decision-making procedures poses a challenge for teachers using these models, as they require subject-specific and education phase-specific guidelines for their instructional decision-making. To prompt the teachers' interest in big data-based decision-making, Wise and Jung (2019) suggest that the use of learning analytics should be aligned with teachers' pedagogical practices. In other words, information should be organized from the perspective of teachers, not data structures, and data ought to be updated in accordance with their instructional needs.

Discussion and Conclusion

From the earlier DIKW model to the more recent big data-based instructional decision models, ongoing are explorations of paths for reaching meaningful decision-making by leveraging educational data. The initial DDDM models had issues with data sources, such as overly focusing on student achievement data while disregarding other types of data (Hora et al., 2014). The advent of big data technology has made it easier to access multiple types of data in colossal volumes. Big data-based instructional decision-making models can provide multiple entry points to analytics for teachers while also presenting various routes to successfully harnessing data to inform decision-making (Zhong & Hou, 2017; Guan et al., 2019; Wise & Jung, 2019; Yan & Wang Wei, 2023).

On the other hand, certain researchers showed concerns about the effectiveness of big data-driven decision-making. Coburn et al. (2012) noted that underlying the interventions aimed at promoting data use was the belief that collecting and analyzing the right data would necessarily lead to valuable information, generating resolutions to chief educational problems and better educational outcomes. In effect, the application of DDDM is potentially affected by multiple factors. First off, the quality of data is the most critical factor. Whether the data is worth considering is contingent on its quality (Lin et al., 2021). For example, the student's self-report may contain insufficiently objective data, which may lead to the teacher's incorrect judgment if included in learning analytics. Thus, it is important to ensure the data incorporated in decision-making is valid, reliable, and pertinent (Agasisti & Bowers, 2017). Second, data abuse may cause severe ethical issues. There is the possibility that the teacher or data analyst may infringe on students' privacy in using their data. Hence, the access to and study of data must be based on the principle of transparency (Agasisti & Bowers, 2017). Third, the conversion of data into evidence for decision-making requires the development of data literacy or data wisdom in teachers. Gummer and Mandinach (2015) defined teacher data literacy as the ability to collect, analyze, and interpret various types of data and to transform the information extracted into actionable instructional knowledge to assist with teaching design. Lastly, the adoption of big data-based instructional decision-making involves cost-related factors. Teacher data literacy training and the deployment of technological tools essential for DDDM bring about additional costs to educational institutions. For many schools, the construction of a digital teaching environment like the smart classroom is still an unaffordable financial burden. Thus, to encourage investment in intelligent education environments from the government and non-governmental organizations, more empirical research is warranted to provide evidence that big data-based educational activities, including DDDM, can significantly improve educational outcomes.

Studies included in our review showcase the researchers' confidence in the positive effects of big data technology in facilitating the teacher's precise and productive decision-making. However, our search for big data-driven instructional decision models is far from exhaustive due to the limitations of the searching method. Future studies should rely on a broader scope of literature search to uncover more models in this area, providing a more comprehensive understanding of the application of big data technology in instructional decision-making. Also, researchers need to pay more attention to the outcomes of these models in teaching practices and focus on exploring more scientific paths for integrating big data technology into instructional decision-making.

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Received: November 10, 2024
Revised: November 27, 2024
Accepted: December 06, 2024

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

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Vol. 25, No. 2, 2024

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