

Preschool Education and its Impact on the Scientific and Research Potential of Rising Schoolchildren: in Favor or Against?

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Abstract: This study examines the correlation between preschool education and the development of scientific thinking in rising schoolchildren. The research involved testing 84 first graders aged 6.5-8 years in two schools in Kazakhstan. The results showed that 52% of the children who attended kindergarten regularly had a high level of scientific thinking, while those with poor scientific skills had less than 20% of kindergarten attendance. The study confirms the interdependence between kindergarten attendance and research potential development. These findings can inform the preparation of rising schoolchildren for scientific activities and further research on preschool education's impact on self-realization in other countries.

Keywords: cause-and-effect relationship; intellectual development; kindergarten; schoolchildren; scientific thinking.

1 Introduction

Throughout life, an individual moves through numerous stages of intellectual, scientific, psychological, and physiological development. Historically, society has managed to adapt to natural evolutionary needs and create various educational processes. Consequently, education as a globalization basis identifies a nation's knowledge and skills, embodies the youth development vector, and brings up generations [1]. Social evolution has made a significant contribution to the actualization of interpersonal relationships, close contact between people, humans and nature, humans and science, and the like. Any organizational structure should be based on mutual respect, harmony, intelligence, and progressiveness [2]. It is education that makes it possible to implement the integration inclinations of the population and to identify science identity for each individual. On the one hand, educational processes are carriers of national customs, creative heritage, culture, knowledge, and scientific facts. However, when considering this issue from a different angle, learning determines an individual's activity vector, their role in the socio-cultural development of society, and develops intellectual independence, and, in fact, scientific thinking [3].

The first and to some extent, the most important stage of education is preschool education. A preschool is an educational establishment that serves to ensure the realization of human rights of their physical, spiritual, and mental development, social adaptation, and a successful transition to the next education system stages [4; 5]. As a result, preschool education mainly aims to create favourable conditions for the personal moral and scientific formation of a child [6; 7]. It is recognized that the continuous transmission of knowledge across generations necessitates the careful consideration of the current innovative, theoretical, and methodological engagement of the youth [8]. This allows one to single out another factor in the educational process: scientific thinking formation in schoolchildren [9; 10].

It should not be unequivocally stated that scientific thinking is only the actual ability of an individual to produce material and/or non-material novelty, which can be useful for society [11]. With a more thorough and comprehensive approach, this type of thinking acts as a special search for knowledge based on the consistent development of new information, testing hypotheses, forming observations and competitive conclusions [12]. Researchers have repeatedly confirmed the fact that the primary manifestation of the active search for various hypotheses appears in children at a very early age, which creates a close connection between preschool education and scientific thinking [13; 14].

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The above theoretical foundations are a catalyst for continuous education system improvement around the world and in separate countries. However, on the other hand, too high expectations form the background for the degradation of the education systems of some developing countries. For example, the Russian Federation preschool education system can be considered. Hence, over the last five years, there has been a reduction in the nationwide number of preschool institutions from 51,000 to 46,000 [15]. In fact, according to forecasts, the number of schoolchildren will increase by 50% by 2025. It is also interesting that in terms of the number of new schools opened annually, Kazan is ahead of all Russian major cities [16]. In this case, based on the research described above, there has been a significant debate among scholars about the effectiveness of the preschool institution on the development of important learning competencies. In addition, there is a growing trend in the modern world to level out the practice of attending kindergarten [17]. It is interesting to know how the latter may impact the intensity of scientific and cognitive development. In this regard, the study aims to determine the effect of secondary education on scientific thinking development. The following research tasks have been identified:

- 1) To study the features of preschool education in Kazan (the Russian Federation) and Nur-Sultan (the Republic of Kazakhstan).
- 2) To analyze the level of scientific thinking in children aged 6.5-8 years.
- 3) To trace the impact of preschool attendance (the city of Kazan) on children's inclinations to scientific thinking.

Consequently, scrutinizing the influence of preschool education on the development of scientific thinking in children will elucidate the significance of kindergartens in the human life trajectory and delineate the overarching characteristics of scientific thinking in the upcoming generation.

1.1 Literature review

Scientific thinking as a separate phenomenon of human intellectual development was considered in the works of many scientists of the past and present [18; 19]. Scientific thinking is part of the so-called 21st-century skills that prepare children to participate in a knowledge society. Scientific thinking has three basic components: creating a hypothesis, experimenting, and evaluating evidence. These components have been studied in children during elementary and middle school [20]. The developmental perspective in the Zimmerman review is derived from cross-sectional studies with several studies investigating scientific reasoning abilities in infants.

Scientific thinking is a multidimensional process consisting of natural and exclusively acquired skills [9]. However, scientists still have certain disagreements about this definition. For example, in a certain context, scientific thinking acts as a systematic and rigorous learning format that should start from an early age [18]. Smith [21] found that preschoolers reacted differently to the identical and distinctive elements of the same object when exploring the toys received during the experiment. Thus, when the first toy was different from the next one, the children spontaneously distinguished the confounding variables. This suggests that at a young age, children exhibit engagement in the analysis and synthesis of the information they receive, thereby reflecting a manifestation of scientific thinking in some form. Moreover, beyond the conventional perspective, certain scholars conceive scientific thinking not merely as a logical phenomenon but as a social construct. Thomas Kuhn [22] suggested that there is no objective theory or data; all scientific activity is based primarily on values. In any case, scientists are guided by personal/cultural values, experiences, and opinions, which determine the questions they ask and the interpretation of their research results. Kuhn's argument emphasizes the difference between facts (information about the world) and values (ideas about what the world is or should be), which fully reflects a child's ability to generate hypotheses when learning about the world [23].

From an early age, children explore the world around them using their senses and forming multiple questions. The scientific process skills of preschool children are thinking skills used to create a knowledge base, solve problems, and draw conclusions [24]. The Meador [25] approach divides these skills into three groups: basic scientific process skills (observation, comparison, classification, measurement, and communication), intermediate process skills (inference and prediction), and advanced process skills (hypothesis generation, definitions, and control variables). The need to develop basic scientific thinking skills in early childhood is caused mainly by the challenge to create a prototypical paradigm of basic scientific thinking skills to optimize them effectively in the future [26].

As van der Graaf, Segers, and Verhoeven [27] point out in their research, kindergarten students acquire subject knowledge while attending kindergarten in the context of matching the expected developmental level for a particular age period of a child. This finding, combined with progress in scientific reasoning abilities, is consistent with the finding that children improve their skills in scientific achievement from the beginning of kindergarten [27]. As scientific progress advances, an individual's conceptual comprehension of the natural and social world, alongside their ability to engage in scientific reasoning, begins to emerge during the early stages of development at approximately the age of 3.

A child's development is determined by their socialization and interaction with society. Quality education at the age of

2-5 aims to form the adaptive aspects of the human character and reduce the complexity of logical thinking [28]. Numerous scholars have widely acknowledged the significant role of preschool educational institutions. Thus, there is an opinion that preschool education can decrease a child's natural developmental process and self-expression [29; 30]. However, most theories still prove the value of preschool education for the further intellectual development of a person [31]. Young children's learning is conditioned by the exploration of the world around them. The analysis and detailed study of the environment within a group are the result of children's curiosity [12] and can lead to active participation in learning [32]. It is also worth noting an example of 7-9-year-old children who completed the task of studying discoveries in a museum with interest; this curiosity was associated with effective learning. Thus, more curious children were faster and learned more from similar studies than less curious children. It was an interesting fact that all these curious children attended kindergarten permanently. While children are rather capable of using questions to express curiosity and explore specific information [33], these skills can and should be strategically supported as questioning plays a fundamental role in science. Moreover, studies by the University of Bamberg (Germany) demonstrate a close relationship between preschool education and primary school education. It was also found that children with higher-quality preschool education demonstrated much better performance in mathematics in their first year of study than other children. The indicators of solving logical riddles, rebuses, and intellectual tasks also increased [33].

2 Methodologies

2.1 Research design

The current investigation comprised four consecutive stages (Figure 1).

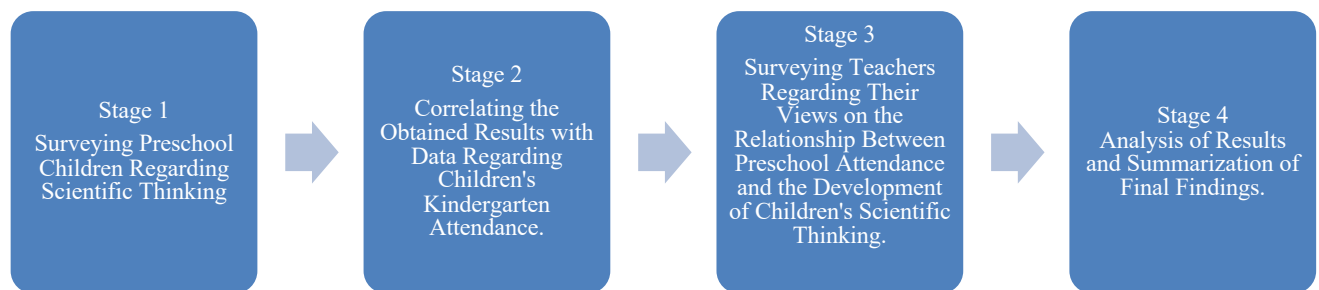


Fig. 1: The stages of the research process.

During the initial stage, a survey was administered to elementary school-aged children to assess their scientific thinking. This survey employed two questionnaires and was conducted with respondents selected from a sample of children intending to pursue secondary education from two countries, namely Russia and Kazakhstan.

The second stage involved the systematic organization of data regarding the attendance patterns of the group of respondents in early education institutions, specifically kindergartens in Kazan and Nur-Sultan. Subsequently, these data were juxtaposed within the context of the correlation between specific levels of scientific thinking in children and the frequency of attendance at these kindergartens.

During the final stage, in-depth interviews were conducted with teachers to confirm or refute the hypothesis, "In your opinion, is there a correlation between a child's attendance at a preschool institution and the development of their scientific thinking?"

Following all the aforementioned components of the study, an analysis was conducted to examine the influence of preschool education on the scientific thinking of future schoolchildren.

2.2 Sample

The research sample consisted of primary school children (6.5-8 years old) who plan to enter Secondary School No. 69 in the Volga region and the lyceum school BINOM SCHOOL in Nur-Sultan. Initially, 237 parents of prospective first graders were informed about the experiment at the parents' meeting. As a result, 25 parents did not give their consent to the survey of their minor children on an experimental basis, 42 ignored the proposal, and 2 parents sent their consent late. Therefore, the research sample included 164 children: 76 (46.3%) girls and 88 (53.7%) boys. The number of study participants was evenly split between representatives of two educational institutions: 84 children from School No. 69 in the Volga region (51.2%) and 80 (48.8%) from the BINOM SCHOOL in Nur-Sultan. At the time of the study, the average age of the children was 7.56 years (SD = 0.75, range 6.5-8 years). The age met the minimum school age requirement of the Ministry of Education and Science of the Russian Federation (6.5 - 8 years). An important aspect

was also the education of the respondent's parents. Thus, the highest education level was classified as high (higher education, 72%), medium (secondary education, 19%) or low (incomplete secondary education, 9%). Based on the information obtained from the parents, it was found that most of the respondents (83%) come from Russian families; the remaining 28 children have at least one parent of Russian descent. When forming the sample of respondents, the principle of maximum homogeneity of the experiment participants was observed: age, gender, and applications for education in educational institutions. Among the key differences is the linguistic aspect - respondents from Russia plan to study in the state language (Russian), while students from Kazakhstan - in Kazakh, considering the bilingual aspect of the country and the predominance of Russian in educational institutions. Based on the total number of first graders attending these schools, the acceptable sampling error (p) does not exceed 4.81.

The in-depth survey involved the participation of 18 primary school teachers from potential educational institutions of the respondents. These teachers were drawn from School No. 69 in the Volga Region and the BINOM SCHOOL lyceum in Nur-Sultan. The gender composition of the teachers consisted of 15 females (83.3%) and 3 males (16.7%). The average age of the participants at the time of the experiment was 35.7 years, with a standard deviation of 1.5 and a range of 29 to 41 years. All participants held Russian certifications and had a minimum of 5 years of experience in the position of elementary school teacher.

2.3 Instrument

When considering the concept of "scientific thinking," it is important to take note of several obstacles that hinder its comprehensive assessment. As such, existing scientific literature lacks unified data concerning the evaluation of this phenomenon, leading to a lack of research methodologies encompassing all manifestations of scientific thinking [34]. Consequently, within the context of surveying younger schoolchildren, it becomes imperative to identify the fundamental characteristics of scientific thinking that are most representative and suitable for analysis within an educational cohort.

Based on certain estimations [9; 18; 22], a propensity for forming causal relationships and exploring cognitive abilities is regarded as an indicator of scientific thinking in children aged 6.5 to 8 years. As a result, two methodologies were adopted to assess the scientific thinking of the respondents.

Within the context of the initial survey, the standardized questionnaire developed by Zambatsevichene [35] was employed to assess the level of mental development in younger schoolchildren. This technique relies on the adaptation of the basic intelligence test developed by Amthauer [36]. The methodology is optimal for use for this study because of its implementation for testing Russian-speaking respondents after modification in the publication of Astapov. The initial appraisal encompassed a set of nine discrete subtests, each purposefully designed to discern and quantitatively measure the children's proficiency in communicative, oratorical, creative, and cognitive domains. This methodology is suitable enough for the present study, but it turned out to be rather impractical due to the age limit. The respondents must be at least 12 years old. Therefore, the test modification made it possible to assess scientific thinking at earlier stages of information coverage and in a simpler way. A simplified intelligence assessment methodology by Zambatsevichene evaluates verbal and spatial thinking, assesses general awareness of the world, the ability to abstract and generalize, combinatorial thinking, and the like. The most important is the possibility of determining the propensity to build cause-and-effect relationships, which is one of the main features of scientific thinking in children. The assessment format of the methodology also remains the most understandable to a young audience, which makes it the most optimal for the present study. The methodology includes 4 subtests (instead of 9 as in the prototype), which were created based on the school curriculum for the present study region. Subtest 1 contains questions that require the respondents to separate significant properties of objects (phenomena) from minor ones. Based on the results obtained, a child's current knowledge can be assessed. Subtest 2 consists of tasks resembling a verbal version of 'The fifth extra' game. The information gathered from the study enables an assessment of the nature of cause-and-effect relationships that children can establish while recognizing and interacting with their environment. Subtest 3 is based on analogy tasks. To complete these tasks, a child must be able to compare the information available with the decisions made promptly. The final subtest is aimed at determining concepts and combining two words that are included in each task of this unit. Each task contains a value in the form of a certain number of points that show complexity. The expected result is assessed by summing up all scores for each subtest (10 questions) and then for the whole test (40 questions). The maximum number of points that a student can receive for completing subtests 1 and 2 is 26 points each, 3 - 23 points, and 4 - 25 points. As a result, the maximum score for all four subtests is 100 points. The study will incorporate both the outcome on a 100-point scale and the intermediary scores for each subtest in its evaluation. In this regard, within the subtests, the respondents will be divided into 3 categories: high, average, and low scientific thinking levels, which are determined by the number of points scored (the higher the score, the higher the affiliation).

The next technique for studying the propensities of scientific thinking is the 'Drawing of a Man' test proposed by Goodenough and Machover [35]. Since this technique is designed to develop a concept of individual child development,

it allows for a more subjective analysis of the development of a sample of preschool children due to their personality traits. It should be noted that this assessment is incomplete. Therefore, it was used in the course of the study only as a supplement to the conclusions about children's scientific thinking determined in the first survey. The assessment technique is rather quick; it requires few resources and makes it possible to evaluate only one drawing of a respondent. This method explores a child's cognitive characteristics, namely perception, the formation of general ideas about the human body, etc., as well as the specifics of the personal emotional sphere. It is necessary to give a child correct and clear instructions to ensure effective task completion; a specific thesis should be formed: 'Please draw a full-sized person. Try to do your best the way you can't. If a respondent asks clarifying questions, for example: 'Boy or girl', the answer should be: 'Draw as you like'. If a child asks about something that contradicts the instructions (for example, 'Can I draw only the head?'), repeat the instructions. Further, the drawing is carefully evaluated in the context of human body details, plasticity, schematics, and other features. Based on a detailed psychological analysis of a child's drawing, their intellectual, creative, and scientific abilities at different stages of development are evaluated. As indicated in the test [37], this technique cannot give a unified assessment of a child's development as each drawing acts as a separate case expressing one's intellectual characteristics and inner self. As a result, all drawings that are similar in terms of interpretation and vision of the instructions described form certain groups that create an additional basis for assessing a child's thinking development in elementary school.

To conduct a comprehensive and structured survey of teachers, they were divided into six groups of three individuals each. The interview sessions lasted 15 minutes for each group. At the outset of the interviews, the teachers were asked the following question: "In your opinion, is there a correlation between a child's attendance at a preschool institution and the development of their scientific thinking?" Initially, they were required to either accept or reject this hypothesis while providing their arguments in support of their stance. Throughout the allocated interview time, the respondents had the opportunity to communicate their opinions or experiences on this matter. This supplementary interview was conducted in addition to the main dependency session, under the observation of field experts from L.N. Gumilyov Eurasian National University's Department of Pedagogy and Psychology.

2.4 Research procedure

The second study stage compares the obtained results with the indicators of children's attendance at preschool educational institutions in the city of Kazan. This information was obtained by surveying respondents' parents. Parents completed specialized forms at the moment when they brought their children in for the survey. They were asked whether their child had attended a preschool educational institution. Moreover, it is imperative to recognize that pertinent aspects, including the distinct features of the preschool educational institution, perceptions of parents and children regarding the kindergarten, and other relevant factors, were not taken into account within the scope of this investigation. It was important to answer the question in the affirmative in case of attending any kind of nearby educational institution for at least 1 academic year. Thus, each of the 4 questions presented in the final survey makes it possible to state the interdependence between the two concepts studied during this experiment.

2.5 Data analysis

Statistica (version 17.0, StatSoft Inc., USA) was used for statistical calculations. After a psychological study, namely, the assessment of participants' propensity for scientific thinking, each child was assigned a number to guarantee research anonymity. Thus, the expected dependence could be observed separately for each individual. The results obtained were thoroughly analyzed by comparing the psychological test indicators with a child's attendance at a preschool educational institution. By the scientific thinking level, each respondent was assigned the colour of a particular group (red - low level, yellow - average level, green - high level). All the above data were entered in the table (Table 1). The conclusions about the examined relationship were derived by conducting a thorough analysis, encompassing both quantitative and qualitative (percentage-based) assessments of the comprehensive data presented in the table. The authors calculated the normality of the distribution of signs (Shapiro-Wilk test). After that, parametric methods of statistical analysis (in particular, Student's t-test) were applied. Differences are significant at $p \leq 0.05$. In addition, whenever significance ranged from $p \leq 0.06$ to $p \leq 0.10$, differences in the signs were considered significant.

2.6 Ethical issues

This study was performed following all methodological requirements for each assessment method. As the respondents' age varied from 6.5 to 8 years, all interviews were carried out with the written consent of one of the child's parents. The experiment was formalized with the participation of the Supervisory Commission of Kazan (Volga Region) Federal University, protocol number: KB No. 359210. At each research stage, there was a social teacher from the Kazan and Nur-Sultan schools. The experiment was carried out in compliance with the sanitary and epidemiological requirements of the COVID-19 quarantine.

2.7 Research limitations

The analysis of the dependency was conducted within a small sample of children (164 respondents) from two educational institutions in two different countries. Specific characteristics related to kindergarten attendance, such as child preferences or dislikes, the curriculum, child inclinations, the extent of parental involvement in the child's development outside of kindergarten, etc., were not considered within the scope of this survey. Consequently, this study cannot be regarded as comprehensive and objective from a scientific terminology perspective.

Moreover, it is noteworthy that, among various assessment methodologies, only two methods were employed, with a detailed description of certain aspects of scientific thinking in younger schoolchildren. As elucidated earlier, the concept of "scientific thinking" encompasses a multitude of aspects, yet this study focused on causal relationships and cognitive abilities as the most common characteristics of this thinking in children of this age group. Consequently, this renders the present study somewhat limited in scope.

3 Results

According to the first stage, only 97 out of 164 children in the sample could complete the test. Therefore, in the course of further analysis, subtests containing tasks that had not been completed (for example, a child managed to complete only 2 subtests out of 4) were not evaluated. It should be explained that partial completion of tasks does not ensure the most effective assessment and does not indicate a lack of scientific thinking in children. Therefore, the final sample consisted of 84 primary school children.

Thus, subtest 1 made it possible to assess children's ability to separate the primary from the secondary and to establish an abstract relationship between the functional properties of objects or phenomena. The children had to choose the thesis from a list of 5 words that best fits a certain category. In general, for 10 subtest questions, a respondent could get 26 points. All subtests make it possible to determine the intellectual and scientific development levels in primary school children with intermediate accuracy. The subtest results showed that the children have a propensity for intellectual development, and, in fact, scientific thinking (59 out of 84 respondents) (Figure 2a).

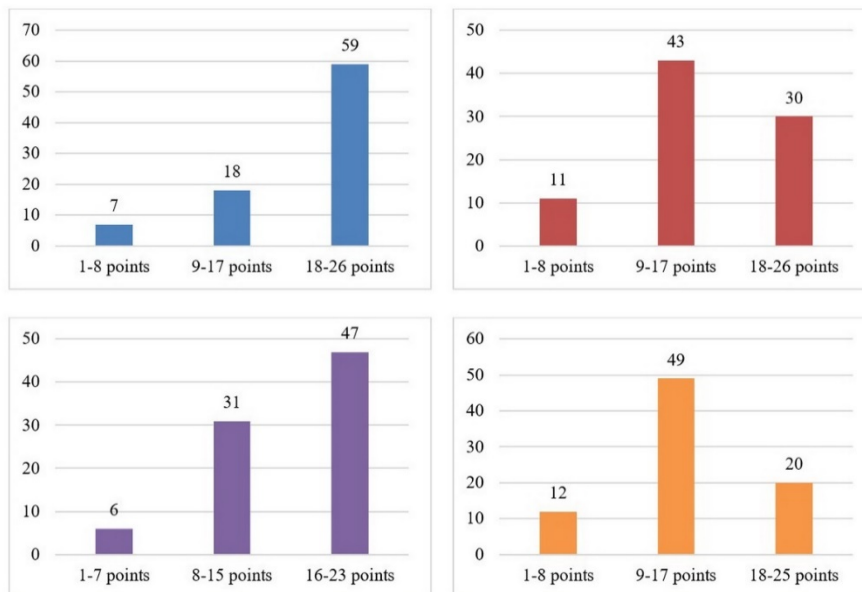


Fig. 2: Number of children with a propensity for scientific thinking (by category of points) for subtest 1 (a), 2 (b), 3 (c), and 4 (d)

This testifies to their general competent format of thinking regarding the objects and phenomena around them, which is progressive by their age (6.5-8 years). Groups with an average and, accordingly, a low level of scientific thinking are the smallest: the group with 0-8 points contains the smallest number of respondents. However, it is worth noting that none of the test participants could answer all the questions correctly. Thus, there were 2 problematic issues that most often caused negative reactions in the children from Kazan and Nur-Sultan: Question No. 3 (In a year, there are: ... 24 months, 3 months, 12 months, 4 weeks, 7 months?) and question No. 7 (The day of the week: ... year, month, week, day, Monday?) [32]. This reflects the complexity of solving similar analytical problems at the age under study.

In subtest 2, there were more respondents with a high scientific thinking level than in the previous one. The children

found the task of eliminating the ‘fifth extra’ word to be much more difficult as none of them managed to correctly answer some questions. These were questions No. 4 and No. 9 [32]. The same was with the geographical tasks of distinguishing a foreign city from other domestic ones as it was outside of preschool children's competence. In contrast, the number of children with average and high levels significantly exceeds the number of respondents with the lowest level. This testifies to their good skills in scientific generalization, observation, and the ability to establish the cause of a certain phenomenon. At the same time, 43 out of 84 respondents (which is half of all primary school children) were in the average category ($p=0.68$). This is a justified result of the subtest given the reasons described above (Figure 2b).

Therefore, considering the results obtained, the children quickly coped with subtest 3. It turned out to be interesting that the testing procedure did not meet the expectations at the beginning of the experiment. This is because almost a third of all children did not understand the subtest instructions at first. However, over time, the children showed rather positive results. Thus, 47 out of 84 children demonstrated good results, which indicates their ability to establish logical connections and compare familiar concepts ($p=0.43$) (Figure 2c). The group of respondents with an average scientific thinking level turned out to be rather big (31 children). It is also worth noting that within the subtest, there was no trend in the complexity of a particular question, as, for example, in subtests 1 or 2.

The final stage assessment demonstrates rather doubtful results among the Kazan respondents (Figure 2d). Consequently, the largest respondent group comprised 49 children who exhibited the capacity for generalization or, in a more scientifically oriented manner, the ability to summarize ($p=0.26$, $p=0.44$). At the same time, the groups of children with high and low levels were almost equivalent ($p=0.71$) (Figure 2d). This may indicate the mediocrity of the respondents' performance in this test, as well as their potential in the context of scientific thinking. Next, the results were entered in each participant's protocol, which made it possible to analyze the general mental development level of primary school children in the city of Kazan ($p=0.53$) (Figure 3).

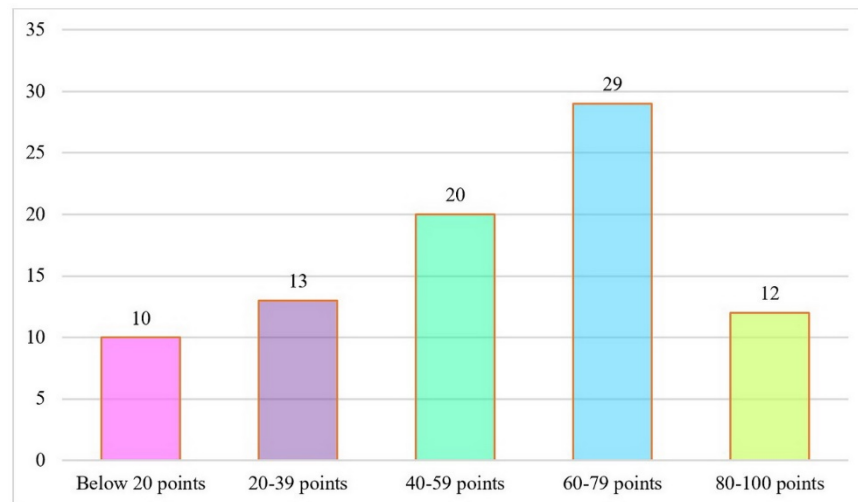


Fig. 3: The number of children by points on the scale (according to the method by E. Zambatsevichene)

Generally, respondent classification according to the total test scores ensures a more detailed assessment with the allocation of 5 groups of individual findings. The group containing the biggest number of respondents scored from 60 to 79 points ($p=0.66$), which characterizes a sufficient level of mental thinking in children. This assessment is based on a good performance in all subtests and includes those questions that the participants failed to answer. The children from this category reacted rather quickly to the tasks set, and the instructions were clear to them. This group is followed by the group of respondents who scored from 40 to 59 points ($p=0.67$). These respondents can be characterized by ambiguous knowledge about the environment, inconsistency in building cause-and-effect relationships, and average reasoning abilities. Such data relate mainly to children with uncertain results and a large number of clarifying questions in the course of the task. It is also worth noting that these test participants often turned to their parents, teachers, or outsiders for help in solving the problem. The following observations for the groups with below-average and high levels of scientific inclinations according to the method by Zambatsevichene turned out to be extremely interesting. Their number is almost equivalent (13 and 12 children, respectively) ($p=0.29$) (Figure 3). By the assessment instructions, children with low scores are classified as schoolchildren with mental inclinations that are inappropriate for their age and a lack of knowledge about the environment and the world. These results may indicate further complexity of studying at school. Therefore, it is necessary to revise these issues. On the other hand, the category with the highest scores shows the same quantitative indicators as the group described above. Children with a high intelligence level and a propensity for scientific thinking and logic make up a small proportion of all respondents. This can affect the comparison of the

results obtained with the indicators of attendance at a preschool educational institution. The category that has not been analyzed yet contains a small number of children. This is the respondent group with the lowest total score that does not exceed 20 points: 10 children with such results have a complete discrepancy between their physiological and mental development at the moment ($p=0.77$). This indicates a further problem of understanding not only scientific but also natural and social processes in the world. The trends analyzed in the study show that the total score of most children in Kazan is satisfactory. Moreover, it is essential to consider that these indicators may be subject to the influence of other external factors, which can impact the accuracy and reliability of the obtained estimates. So far, extraneous factors include a respondent's family relations, socialization level, personal character traits, and the like. It should be noted that some questions of this methodology turned out to be imperfect as none of the children could answer them, which is an aspect of partial influence on such conclusions.

The next stage is another assessment based on the 'Drawing of a Man' test developed by Goodenough and Machover. According to the instructions, the children had to draw a person that can characterize their scientific, mental, and intellectual development. As each drawing reflects the inner 'self' of each participant, they were systematized.

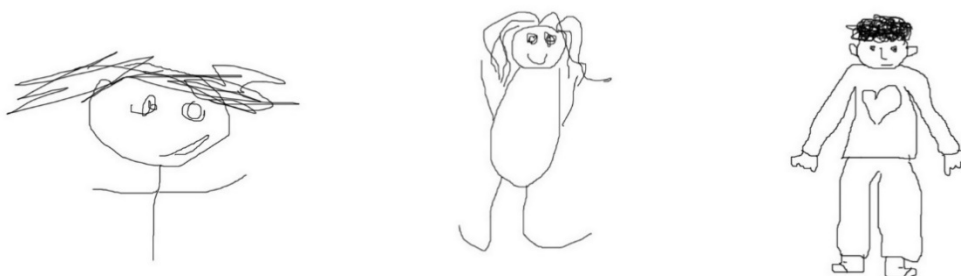


Fig. 4: Schematic drawings by category (according to the method by Goodenough and Machover)

Consequently, the results were divided into 3 groups according to the assessment criteria and reflected the degree of mental skills development. It is a positive fact that all respondents wanted to perform this task. Most children (63 out of 84 people) ($p=0.25$) asked clarifying questions described above. These were answered according to the methodology instructions. Therefore, the drawing procedure was fair for all primary school children of the Kazan region. The drawings demonstrate that all groups have a different view of the task, which reflects their mental and scientific inclinations. Unfortunately, the test instructions provide a rather conditional scale for evaluating children's drawings, and their analysis subjectivity may interfere with the actual study of the issue. Thus, within the framework of the study, clear requirements were identified. Table 1 describes clear criteria and their correspondence with the qualitative assessment of each drawing from the groups.

Table 1: Criteria for evaluating the results and their analysis by groups of drawings (according to the method by Goodenough and Machover)

Criterion	Group		
	A	B	C
All basic human body parts	Low level	Average level	High level
Plasticity/schematicity	Low level	Average level	High level

The criterion of 'all basic human body parts' makes it possible to track the correspondence between a child's worldview and the scientific axioms of the world creation, their attention to obvious details, as well as the observation. For example, Figure 4a shows that a person is missing some body parts (legs, nose, ears), which may indicate a low level of intellectual development in a child aged 6.5-8 years. The next drawing shows us a person with one part of the body missing (fingers), which allows us to conclude the average level of intelligence in group B (Figure 4b). The authors of the technique also note that similar results can be obtained due to a child's inattention, which is a rather negative scientific thinking trait. The final drawing represents group C. In this case, the drawing resembles a real person (according to the criterion of 'all basic human body parts'). Thus, these children exhibit a pronounced propensity towards continued and progressive intellectual development.

The second criterion is also important as it evaluates the drawings from a qualitative point of view. Plasticity indicates a high level of a child's intellectual development. Examples of such drawings can be found in category C. They do not have clear transitions from one part of the body to another, that is, the drawing corresponds to the real human body structure. The legs (in the figure, this is a man in trousers) converge to one point at the top. It is immediately obvious that the child who drew this picture tried to convey the real human body lines. Drawing plasticity indicates the optimal

level of a child's development within the age range under study and the potential for scientific thinking, which is more important in the current experiment.

From another assessment perspective, a drawing depicts each body part separately from the other. This may refer to the transitions between the neck and the body as shown in Figure 4a. The methodology authors confirm that such a pattern is a manifestation of general or partial infantilism. The psychodiagnostic description of such drawings reflects respondent group C and indicates, as described above, an unacceptable level of scientific thinking.

The final assessment is the analysis of Figure 4b, which is assigned to group B and is characterized both by schematic lines and plasticity. It seems that some body parts are glued while others do not have clear transitions. For example, the arms grow organically from the shoulders, and the legs are separated from the body. This does not indicate a low but rather an insufficient level of scientific thinking that requires pedagogical corrections.

The results obtained based on a quantitative approach in terms of the number of children from Kazan by each group show that there is a noticeable tendency towards a sufficient scientific thinking level in most respondents (Figure 5). Thus, the drawings of 53 out of 84 children were similar to Figure 4c, which confirms their optimal level of abstractness, logical thinking, and intelligence ($p=0.3$). Slightly more than a third of the research participants demonstrated an average level of the qualities under analysis. Many drawings contained all the relevant elements of the primitive human body structure. A mediocre result was found due to the insufficient plasticity of the drawings by group B. Group A is the smallest in terms of the participant number (only 7% of the total sample) ($p=0.81$). Based on this methodology, it was concluded that the intellectual, mental, and scientific potential levels of the children from Kazan who plan to enter school No. 69 and BINOM SCHOOL are satisfactory.

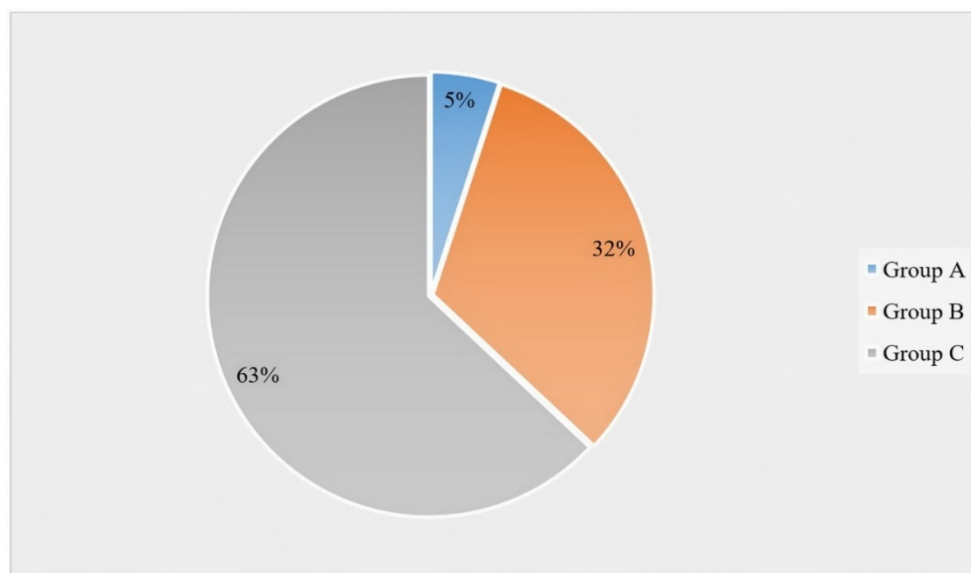


Fig. 5: The percentage of the number of children by category (according to the method by Goodenough and Machover)

The second research stage was a comparison of the results obtained and the identification of certain trends. It should be noted that the first methodology was fundamental, so the conclusions regarding children's scientific thinking levels were formed to a greater extent based on this particular analysis. On the other hand, the abstract test by Goodenough and Machover showed almost the same results as the previous technique, that is, it overwhelmingly fulfilled its function as an amplifier of optimal results. Based on the two methodologies, it was found that 40 individuals had high scientific thinking and intellectual activity levels while there were 19 children with low levels ($p=0.34$). There were 27 people with average scientific thinking and intellectual activity skills ($p=0.27$). As a result, children's scientific thinking indicators were entered into the table under their numbers and marked with colours (Table 2).

Table 2: Comparison of the psychodiagnostic results (based on the methodology by Zambacevichene; methodology by Goodenough and Machover) with the children's kindergarten attendance indicators.

Scientific thinking level / kindergarten attendance	Children who participated in the study (No.)						
	1	2	3	4	5	6	7
	8	9	10	11	12	13	14
	15	16	17	18	19	20	21
	22	23	24	25	26	27	28
	29	30	31	32	33	34	35

	36	37	38	39	40	41	42
	43	44	45	46	47	48	49
	50	51	52	53	54	55	56
	57	58	59	60	61	62	63
	64	65	66	67	68	69	70
	71	72	73	74	75	76	77
	78	79	80	81	82	83	84

Red indicates the low-performing group while green denotes the high-performing group. The reference group is marked in yellow. Hatch fill indicates a positive result in the preschool attendance survey. Thus, the table fully reflects the qualitative study results. According to the table, only 4 out of 19 children attended kindergartens and, at the time of entering school, had a low propensity for scientific thinking ($p=0.56$). The group in the middle-received collision results in 10 boxes accounting for about 37% of the total number of its participants ($p=0.49$). At the same time, it was found that the children with high indicators attended a preschool educational institution. The table shows that almost all participants, who are marked in green, have hatching (in quantitative terms, 29 out of 40 children), which fully explains the expected trend ($p=0.58$). Based on the analysis, one can conclude that there is a real relationship between a child's scientific thinking level and their kindergarten attendance as exemplified by the children from Kazan, the Russian Federation. This fact is explained both from the theoretical perspective of intensive identification by the individual of natural phenomena and objects with the help of collective perception and practically by the existing dependence at the research level. It is worth noting that scientific thinking is a completely acquired feature. The presence of average comparison results is also justified: in groups with low and average intellectual development levels, some children actively attended kindergarten. However, dependence rather characterizes the general interconnection between intensive mental development and the effect of an individual's early socialization.

At the same time, in-depth interviews with teachers indicate that preschool children have significantly better levels of scientific and creative thinking than those who do not attend preschool. According to teachers, such children have significantly higher levels of communication and creativity, and are more likely to understand the content of the task at hand. That is, in response to the hypothesis, about 88% of teachers confirmed the investigated interdependence ($p=0.93$).

4 Discussions

The empirical study of the relationship between the scientific thinking development in children aged 6.5-8 years in Kazan and their attendance at preschool educational institutions indicates the obvious dependence between the two indicators. At the same time, the result obtained turned out to be rather expected from the perspective of a strong connection between kindergartens and a child's intellectual development both on theoretical and practical grounds. According to American scientific and administrative studies, any preschool training contributes to the effective mastery of the learning material and the formation of general literacy principles and academic achievement of a child [38]. Thus, from childhood, an individual becomes part of an unfamiliar social group, develops a range of communication and organizational skills, finds their position in society, learns to solve problems on their own, and explores the environment much more actively. It should be noted that an important aspect in the context of any education format is its qualitative rather than quantitative indicator. The essential criteria for optimal preschool training are the innovation level, staff qualifications, facilities, financial indicators, and others. In terms of both tangible and intangible factors, preschool education around the world differs significantly [39]. According to the latest data from the global preschool education report, there is a fairly large gap between the views of child development in Eastern Europe and America. As a result, the specific conditions of preschool education in Kazan, and generally in the Russian Federation, are a significant factor affecting the present research results.

The data obtained based on the analysis of Russian studies devoted to preschool education effectiveness in the Russian Federation, as well as in the Republic of Kazakhstan, demonstrate disappointing results: there were no high indicators obtained by any preschool educational institution. The 'Favorable learning environment' indicator was the most important for the assessment. The following results were obtained: almost all kindergartens were characterized as 'good' and some of them 'satisfactory' [40]. This fact indicates the low attendance at preschool educational institutions in the Russian Federation and the Republic of Kazakhstan. For example, when comparing the Russian indicators of kindergarten attendance with the American ones, the ratio is 69% and 91%, respectively. In the present study, this trend was also observed in Kazan [41]. This indicator is very high in the Netherlands (98.7% of children regularly attend a preschool educational institution) [2] while the Singapore indicator is the highest (99.1% of children) [42].

It cannot be stated that it is only a preschool educational institution that affects scientific thinking formation. Thus, according to researchers from the National Institute of Education in Singapore, there is a close connection between a

child's intellectual development and their upbringing and relationships with parents [43]. It was announced that a two-parent family has a positive effect on a child's academic performance as there the child receives enough attention. Singapore studies are also a good example of the emergence of the Asian parenting model and learning. The attraction of funds and resource support for educational institutions is the basis for ensuring scientific and technological progress in a child's thinking skills development [8]. Thus, the official regulations of the Ministry of Community Development in Singapore cities regulate the provision of preschool educational activities by age in language arts, manipulative and constructive games, music and physical education, arts and crafts, mathematics, sand and water games, dramatic play, science, and social science. In addition, there are learning places to practice role-play/science/nature, libraries/books, and a place to complement current topics [43]. This variety of activity choices in preschool institutions makes it possible to identify a child's personal creative/professional inclinations, which will further influence their scientific thinking development [44]. Considering the findings of this research, it is noteworthy that the educational institution itself can serve as the initial catalyst for the development of scientific thinking. Thus, it is the teachers in preschool settings who play a crucial role in fostering early scientific thinking by providing children with opportunities for exploration and experimentation. Encouraging children to ask questions and seek answers within the framework of preschool education also proves beneficial. When children perceive that their curiosity is encouraged, they are more inclined to explore and learn, thereby preparing them for the principles of learning in secondary school [45].

On the other hand, the development of a child's scientific thinking at an early age can truly realistically begin with an assessment of their statistical skills [18]. For example, over the past 10 years, researchers from around the world have systematically given young children evidence and then observed the conclusions they draw [46; 47]. This can be explained by the fact that, to a large extent, children use already-acquired data to formulate and test a hypothesis or theory in much the same way as scientists do. As noted in the study, people who are involved in science learn about the world in three ways: analyze statistical patterns, conduct experiments, and learn from the facts and ideas of other scientists. The experiments described show that the learning process in preschool educational institutions occurs similarly. Moreover, it is reported that they often resemble ideal Bayesian students, which allows probabilistic models to make accurate and detailed predictions about preschool education. Nevertheless, the article questions the unequivocal influence of preschool institutions on the development of children's scientific thinking. This is due to the acknowledgement that kindergarten is not the sole factor affecting the development of scientific thinking in children. The authors highlight the presence of other equally important factors, including:

- The family environment,
- Socio-economic status,
- Personal characteristics of the child, such as abilities, interests, and motivation [11].

It is essential to note that all these factors interact with each other, and their impact on the development of scientific thinking may vary among different children. For instance, a child raised in a family that values education and science is more likely to develop an interest in science than a child raised in a family where science is not a priority [48].

However, Dutch scientists argue about the origin of scientific thinking and its development in the course of studying specific scientific disciplines rather than at the early stages of identifying natural phenomena and objects [49; 50]. Thus, in the course of the study, scientific thinking is interpreted as a multidimensional system based on certain theoretical skills acquired in a particular subject. During the experiment, it was noted that children of 2-4 grades showed intellectual aspiration but mostly at a primitive level. It is worth noting that the first attempts to form and verify hypotheses are observed in preschool children, which indicates the presence of scientific thinking at a very early age. These data are not rejected but when considering the issue in more detail, one must take into account the fact that a child's brain activity is competently stimulated from the earliest years. This assessment is interesting from the perspective of improving actual manifestations of scientific thinking among schoolchildren who have an approximate idea of their personal and professional interests. Denying the fact of a child's propensity to active or passive scientific activity due to their belonging to a certain social group of a preschool institution can stimulate the loss of this potential at the early stages of its development.

5 Conclusions

The research confirms the impact of attending a kindergarten on the scientific thinking development in children aged 6.5-8 in the example of Kazan (the Russian Federation) and Nur-Sultan (the Republic of Kazakhstan) schools. The choice of regions is explained by the intensive development of their preschool education systems. Thus, this issue is relevant for the areas. The results obtained indicate a high correlation between the intellectual potential development of children entering school and their kindergarten attendance. A general trend towards the average level of scientific thinking among all respondents was noted; in addition, there were some questions that none of the respondents could

answer. In percentage terms, most children with a high propensity for scientific thinking at an early age attended a preschool educational institution (72.5%). At the same time, the group of children with poor intellectual inclinations contains less than one-fifth of the respondents who attended a kindergarten. This indicates that scientific thinking at the age under study has only the potential for development so one should not expect a clear formulation of logical hypotheses and conclusions. Therefore, children who attended a preschool educational institution have a significantly higher level of scientific thinking than young individuals who did not attend kindergarten. In general, most children in the selected regions of the Russian Federation and the Republic of Kazakhstan, namely, 43 out of 84 respondents, attended a preschool educational institution.

The data obtained can be used in further research on this problem but on the example of other regions and other techniques. At the same time, this study has a recommendatory place for parents of preschool children to agitate them to attend kindergarten. The results demonstrate the impact of kindergarten attendance not only on scientific thinking but also on the further vocational and personal development of a child. Future researchers may investigate in more detail the impact of kindergarten attendance on the level of other abilities children will use in school, such as the quality of reading and writing, and proficiency in mathematics.

Conflicts of Interest Statement

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Ethics Statement

This research did not require ethical approval. Data Availability Statement Data associated with the manuscript is public and has been referenced appropriately.

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