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"Risky Literacy" in Preschool Children: A Conceptual Model of Forming Safe Behavior in Play Activities

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Abstract

The study was aimed at determining the main mechanisms of formation and pedagogical conditions for the development of risk literacy in preschool children. In the article, risk literacy was interpreted as an integrated competence aimed at recognizing, assessing and regulating risk in the process of play. 269 children aged 4–6 years participated in the study. A mixed design was used: assessment of 8 behavioral indicators of risk literacy and observation protocols in natural situations. Special tasks for the development of executive functions were also used. Data analysis consisted of descriptive statistics, correlations, ANOVA/Kruskal–Wallis, regression modeling, exploratory factor analysis.

The results indicated that risk literacy consists of cognitive, emotional-volitional, behavioral-regulatory and social-communicative components. It was established that different types of game activities are differently aimed at the development of these components. Pedagogical conditions emerged as important predictors of risk literacy: adult scaffolding (β = 0.28), dialogical discussion of risk (β = 0.22), and collaborative rule-making (β = 0.17). Cluster analysis revealed three typical profiles of children: cautious observers, emerging regulators, and competent risk navigators.

The results obtained had practical significance for preschool teachers, as they allowed us to consider play as a tool for forming safe behavior through managed risk.

Keywords:

Risk Literacy; Risk Play; Preschool Age; Self-Regulation; Safe Behavior; Pedagogical Conditions; Game Activity

Introduction

In the social, technological, and cultural changes, the formation of safe behavior of preschool children is becoming particularly relevant. Preschoolers actively interact with various risk situations every day. This is noticeable both in the real environment and in the digital or gaming space. Thus, the world of pedagogical and psychological literature operates with the concept of "risk literacy", which implies the child's ability to recognize potential dangers, assess them, and make responsible decisions (Eager et al., 2025; Williams et al., 2025). This is especially important for preschoolers,

because playing activities are key in this period and act as a field for the emergence of behavioral risks. Despite the growing interest in the problem of safe behavior, the scientific problem is still defined in the insufficient level of development of conceptual models that would integrate important parts of risk literacy in the environment of children's gaming activities (Kubitskyi et al., 2022; Semigina, 2022). In particular, the current scientific literature describes various aspects of emotional competence, self-organization, social interaction or safety in the educational environment. However, the formation of models that determine the mechanisms of formation of safe behavior based on play is almost absent. This has complicated the formation of effective pedagogical strategies and programs.

Therefore, the purpose of the study is to form and theoretically substantiate a conceptual model of the development of risk literacy and safe behavior of preschool children in play activities.

In accordance with the purpose, there are the following main research questions:

1. What cognitive, emotional-volitional and socio-communicative components make up the content of the concept of "risk literacy" in preschool age?
2. What types of play activities most intensively form the skills of safe behavior and risk assessment?
3. What pedagogical conditions and interactions of an adult with a child contribute to the development of risk literacy?
4. How do pedagogical strategies in play environments influence the development of risk literacy components?
5. Which indicators are the most sensitive and valid for assessing risk literacy in preschool children?

Therefore, the scientific novelty is that a holistic model of risk literacy in preschool children has been proposed, which consists of cognitive, emotional, behavioral and social dimensions. The work will also identify mechanisms for the formation of safe behavior within the framework of game activities.

Literature Review and Theoretical Framework

The concept of "risk literacy" in preschool education

In modern scientific literature, the concept of risk literacy is defined as the ability of a person (in this case, a child) to realize the nature of risk, correlate danger with the context, predict consequences and choose an adequate course of behavior (Nikiforidou, 2017). In early childhood, this is not just a "rational calculation", but also the development of primary risk thinking based on the involvement of experience, emotional experience (feeling) of the situation and social discussion with adults and peers (Bowden et al., 2025; Nikiforidou, 2017). At the same time, the scientific literature indicates that risk literacy in preschool age involves the ability to recognize "risk signals" in a situation; tolerance for uncertainty; elements of critical and cause-and-effect thinking (Deniz & Cevher Kalburan, 2024). It is also emphasized that the experience of independent decision-making within the framework of managed risk is also a key aspect (Karaca et al., 2024). It is important that modern researchers have proposed to go beyond the narrow "physical risk" and described risk as a broader pedagogical resource that manifests itself in the cognitive, social and emotional spheres (Karaca et al., 2024).

Risk (adventurous) play as a natural mechanism of development

The leading theoretical source is the concept of risky play. Scientists have described the basic categories of such a game (height, speed, "dangerous" tools, dangerous elements of the environment, struggle-fuss, "disappearance" from the adult's field, etc.) (Deniz & Cevher Kalburan, 2024; 2025). These aspects are also regularly confirmed in other modern works. At the same time, other scientists have indicated that risky play allows you to form motor competence and spatial orientation (Karaca et al., 2024). Also, some researchers have determined that it allows you to train self-control and the limits of your own capabilities (Ko & Cho, 2021; Pigott et al., 2025). According to other works, the game contributes to the development of a realistic perception of risk instead of fear or impulsivity (Hedegaard, 2019; MacQuarrie et al., 2022). Separately, the implementation of gaming activities allows for maintaining psychological well-being (in particular, it reduces anxiety due to "managed fear") (Fleer, 2011; Ibrahim et al., 2018). Thus, risky play is considered an important condition for optimal development based on the principle of "as safe as possible".

Safe behavior: basic principles of formation

Contemporary scientific literature indicates that safety in preschool institutions is based on a zero-risk strategy, which involves the maximum elimination of any potentially dangerous elements in the environment (Jia et al., 2025; Karabon & Steiner, 2020). This aspect was characteristic of traditional injury prevention models, which aim to reduce childhood injuries by regulating space, restricting active forms of play, and creating a "hyper-controlled" environment. However, modern research has shown that excessive protection, while ensuring safety, can have the opposite effect reducing independence, increasing children's anxiety, and limiting opportunities for sensorimotor and social

development (Li et al., 2024; Little et al., 2012). At the same time, new approaches in injury prevention research have pointed to the importance of moving from a process of "risk avoidance" to controlled risk (Betts et al., 2021). In this system, an important task for adults is to eliminate risky situations and teach children to distinguish between risk and hidden danger. As noted in other studies, it is important to make informed choices, predict consequences, and apply appropriate self-protection strategies (Hsueh & Chen, 2025). This approach is based on evidence that children who have never had the opportunity to encounter mild, controlled risk are less able to recognize real threats in real-life situations.

Deniz & Cevher Kalburan (2025) pay particular attention to the phenomenon of free play with moderate uncertainty. It is precisely such play situations, in particular climbing, balancing, fast movement, and games in open spaces, that enable children to develop self-regulation, internal control, and the ability to stop in time. However, other studies emphasize that participation in risky play correlates with reduced anxiety, increased self-confidence, and the development of motor skills (Chaipidech et al., 2022; Maksymchuk et al., 2019b).

Thus, the modern concept of safe behavior is based on the idea that measured risk is a natural and necessary learning resource (Luo et al., 2024). This has clearly changed the key focus of educational practices. As scientists have emphasized, it is now important to teach children to act autonomously, safely, and consciously in complex and unpredictable situations (Bub et al., 2025).

Modern researchers have pointed out that the position of an adult should be that of a facilitator rather than a controller. They should create "managed challenges" and organize the environment so that it contains complex but accessible tasks for the child (height, movement, balance, structures, tactile materials, spacious locations) (Deniz & Cevher Kalburan, 2024; 2025). Adults should also anticipate and eliminate hidden dangers that children are unable to recognize. These include slippery surfaces, carelessly installed structures, and technical malfunctions (Cheng et al., 2025; Smolinski, 2022). It is also important to gradually transfer control to the child and give them the opportunity to assess the situation and make decisions on their own.

However, contemporary literature does not pay much attention to the empirical aspects of this problem. There is also still a lack of sufficiently integrated models that combine risk literacy and safe behavior specifically in the play activities of preschoolers.

In addition, most studies focus on the physical dimension of risk. However, the social-emotional and cognitive mechanisms of safe choices in play are described only fragmentarily. It is also noticeable that the criteria for assessing risk literacy at the age of 3–6 years, especially in natural play, are insufficiently developed. This work aims to fill these gaps by developing and theoretically substantiating a conceptual model for the formation of risk literacy and safe behavior in preschool children in play activities.

Thus, the analysis of the literature indicated several key gaps. First, there was a lack of integrated models that combine cognitive, emotional, behavioral, and social aspects of risk literacy in early childhood. Second, empirical studies have rarely examined these components within natural play contexts. Third, existing approaches tended to focus on isolated dimensions of risk rather than their interaction. To address these gaps, the present study proposed a conceptual model that integrates these components within the framework of play-based learning and empirically tests its structure.

Theoretical framework and conceptual model

Several complementary theoretical lines have been integrated to form a conceptual model. In particular, the sociocultural theory of development and play (L. Vygotsky, D. Elkonin, B. Rogoff) has become important (Pressley & Roehrig, 2014). For these scientists, play is the leading activity of preschoolers, in which higher mental functions, volition, rules, and self-regulation are formed (Pressley & Roehrig, 2014). In this sense, risk literacy is formed on the basis of joint play in risky situations, mastering rules, and gradual independent decision-making. The work of Baudonnière et al. (1989) is also important, as it contains an analysis of key aspects of the early development of communicative competences in children.

The ecological theory of development, initiated by W. Bronfenbrenner, also played an important role (Schürer et al., 2025). A child's safe/risky behavior is determined by individual characteristics and the environment: family, preschool, yard/street culture, and society's normative expectations regarding "safety." For this reason, overburdening the environment with prohibitions reduces opportunities for learning about risk. The theory of risky play and risk competence, as expressed in contemporary works, predicted that risky experience can be acquired through play. The theory indicated that repeated episodes of risky play translate into risk assessment skills.

Therefore, the risk literacy of preschoolers in play will involve the integration of the following aspects:

Cognitive: risk recognition, basic prediction of consequences, distinction between "risk" and "danger."

Emotional-volitional: experiencing controlled fear, confidence, tolerance for uncertainty.

Behavioral: choosing a strategy of action, following rules, self-control, and "stopping."

Social: agreements in the game, mutual safety control, and asking for help.

Thus, this system formed the framework for a conceptual model of safe behavior formation in play activities (See Table 1).

The indicators of the formation of risk literacy in children aged 3–6 played an important role in the model:

1. Recognition of risky signals. This indicator assumes that the child is able to notice elements of the environment or situation that may be potentially dangerous (slippery surface, unstable structure, fast movement of another child).

2. Predicting consequences. This indicator determines that the child can predict what may happen as a result of a certain action (I will fall, I may hit a friend, the structure will collapse).

3. Ability to stop independently. Assumed that the child has the ability to stop or slow down before crossing the line.

4. Internalization of safety rules. assumed that the child follows the rules formed together with an adult/group, without waiting for reminders.

5. Asking for help. The child is able to realize a situation that requires the support of an adult or peer.

6. Emotional regulation in risky situations. The child is able to regulate fear, excitement, excessive joy, or worry in complex play.

7. Coordination with peers and mutual control. The child takes into account the presence of others in the game, warns of risks, coordinates actions, and adheres to mutual agreements.

8. Safe problem solving. The child can suggest an alternative, safer way to achieve a goal in the game (See Table 2).

Table 1.

Blocks, mechanisms, conditions and expected results from using the model

Block	Mechanisms	Pedagogical Conditions	Expected Results
Cognitive	Risk recognition; Cause-effect reasoning	Dialogic inquiry; Guided reflection	Accurate risk assessment
Emotional-Volitional	Tolerance to uncertainty; Fear regulation	Supportive scaffolding; Safe exposure	Emotional stability in risk
Behavioral/Self-Regulation	Impulse control; Action planning	Structured challenges; Rule co-creation	Safe decision-making
Social	Negotiation; Mutual monitoring	Cooperative play; Adult modeling	Help-seeking and teamwork

Table 2.

Description of indicators for the formation of safe behavior in the game

Indicator	Description
Risk Signal Recognition	Child identifies potentially risky elements in a scene/game.
Prediction of Consequences	Child can verbalize what may happen if action continues.
Self-Stop Ability	Child demonstrates ability to stop before crossing unsafe threshold.
Rule Internalization	Child follows co-created safety rules without reminders.
Help-Seeking	Child asks peer/adult for assistance in uncertain situations.
Emotional Regulation	Child manages excitement/fear during challenging play.
Peer Coordination	Child warns peers or adjusts behavior to maintain group safety.
Safe Problem-Solving	Child proposes safer alternative actions.

Method

Research design

The proposed conceptual model of risk literacy serves as the theoretical basis of the study. The empirical part is aimed at its primary validation through the measurement of structural indicators of the model (cognitive, emotional-volitional, behavioral and social). This approach allows us to assess the correspondence of real behavioral manifestations to the predicted components of the model. The proposed conceptual model served as the theoretical framework for the study. The empirical part was aimed at its initial verification by analyzing the correspondence of behavioral indicators to the model structure, rather than at full-fledged cause-and-effect modeling.

Hence, the study was of an empirical-conceptual type and aimed at determining risk literacy and safe behavior of preschool children in play activities. For this purpose, a mixed design was chosen with the dominance of the quantitative component, which combines standardized measurement of risk literacy indicators. Systematic pedagogical observation of children's behavior in a natural play environment also played an important role. According to this design, the quantitative component made it possible to determine the level of formation of each of the indicators (cognitive, emotional-volitional, behavioral, social) and establish relationships between the components of the model. The qualitative component was aimed at clarifying the main mechanisms of risk literacy formation based on the analysis of game situations and the description of children's risk-choice scenarios.

Participants and sample

269 preschool children participated in the study. The sample was carried out according to the principle of purposeful cluster selection based on preschool education institutions in the city of Kyiv. This ensured the representativeness and naturalness of the observation of play activities. Clusters were individual groups of kindergartens within which children were involved in the procedure.

Inclusion criteria in the sample:

1. Child's age within the preschool period (3–6 years);
2. Systematic attendance at a preschool educational institution;
3. Absence of medical contraindications to participation in active play activities;
4. Informed consent of parents/guardians to the child's participation.

Exclusion criteria:

1. Irregular attendance at kindergarten;
2. A health condition that does not allow participation in mobile or plot-role-playing games;
3. Lack of parental consent.

To avoid systematic errors, the sample included children from different socio-cultural conditions and play environments (different types of groups/ kindergartens). The sample included children aged 3 to 6 years. The distribution by age subgroups was as follows: 3–4 years – 28%, 4–5 years – 30%, 5–6 years – 42%. The gender distribution of the sample was relatively balanced (45% boys, 55% girls). Children were recruited from different types of preschools (public and private), which allowed for the variability of the educational environment to be considered.

Instruments and Procedure

The instruments were formed as an operationalization of the key blocks of the proposed conceptual model. Each indicator corresponded to a specific mechanism or component of the model. This made it possible to conduct its empirical verification.

Hence, to determine the level of risk literacy and safe behavior of preschool children, standardized protocols and author's checklists were used (See Appendixes 1-4). The toolkit consists of four blocks that correspond to the structure of the conceptual model - cognitive, emotional-volitional, behavioral and social.

1. Checklist "Indicators of risk literacy" (8-point scale).

This tool was specially developed to assess behavioral manifestations in natural play. Each of the 8 indicators (recognition of risks, prediction of consequences, self-stopping, internalization of rules, assistance, emotional regulation, coordination with peers, safe problem solving) was coded on a 4-level scale:

1. not manifested;
2. manifested episodically/with a prompt;
3. manifested stably;
4. manifested proactively and generalized.

This checklist made it possible to form an individual profile of each child and a group distribution of competence levels.

2. Protocol for pedagogical observation of game situations

This protocol was used to record typical scenarios of

risky play: climbing, balance, fast movements, use of materials, plot-role interactions.

The protocol contained: 1. description of the game conditions; 2. risk element; 3. child's reaction; 4. social interactions; 4. teacher's comment; 5. interpretive notes.

Accordingly, this tool made it possible to identify key mechanisms for the formation of safe behavior, which cannot be measured only quantitatively.

3. Screening kit for assessing self-regulation (adapted version of EF-tasks)

This tool consisted of short game tasks aimed at assessing executive functions. In particular, the following tasks were used:

"Stop-Start" (impulsivity and inhibition);

"Color rules" (cognitive flexibility);

"Repeat the path" (action planning).

Such tasks made it possible to describe the key cognitive skills associated with behavior in risky play.

It is important to clarify that tasks assessing executive functions (EF) were not included in the integral risk literacy index. They were used as auxiliary (external) variables to assess the level of self-regulation as a theoretically related construct. In particular, the results of EF tasks were used in correlation and regression analysis to identify relationships between executive functions and components of risk literacy (cognitive, emotional-volitional, behavioral and social). Thus, EF indicators played the role of independent explanatory variables, and not a structural component of the integral risk literacy index.

The content validity of the instruments was ensured by expert assessment of the indicators' compliance with the theoretical model of risk literacy. Before the main study, the instruments were tested on a pilot sample of children, which allowed us to refine the wording of the instructions and adapt the tasks to age-specific characteristics.

4. Questionnaire for teachers

This tool contained 12 statements about the child's typical actions in various game situations (scored on a scale of 1–5). It includes three areas: 1. Propensity for risky play; 2. Behavioral self-control; 3. Social interaction in risky situations. Overall, this approach strengthened the validity of the observations.

The study was conducted in the natural conditions of preschool educational institutions and included several stages. At the first stage, consent was obtained from parents to conduct the study. Then, teachers were instructed on the use of the checklist and protocols. Also at this stage, play areas were arranged in accordance with the standards of "managed risk" (without hidden dangers).

At the second stage, basic observation took place. It involved systematic observation of children in various types of play (free, mobile, story-based, constructive) over several days. For each child, the following were recorded: 1. 3–5 game episodes; 2. performance of 8 indicators according to a checklist; 3. description according to the protocol. This stage made it possible to assess the initial level of risk literacy.

At the third stage, self-regulation assessment (EF-tasks) took place. In particular, short individual testing is carried out in the form of a game. Children performed 3 tasks, each of which is assessed according to a standardized scheme. Duration - approximately 5–7 minutes per child.

At the next stage, additional expert assessment was carried out by teachers. In particular, the questionnaire was filled out by teachers who regularly observed the child in normal conditions (at least 3 months).

At the fifth stage, data were agreed upon and individual profiles were formed. Observations from various game situations were integrated and teachers' assessments were compared with an objective checklist. Thus, a risk literacy profile was formed for each child and for the group. At the last stage, analytical processing, quantification of indicator levels and analysis of connections between model blocks were carried out. Data synthesis was also aimed at comparing the obtained behavioral patterns with the predicted structure of the model.

Data analysis

Data analysis involved empirical testing of the structural components of the proposed conceptual model of risk literacy. First, a preliminary data check was carried out. For each child, the following were compiled: scores for 8 indicators of risk literacy (4-level scale); results of self-regulation screening (three completed EF tasks); expert assessments of teachers; codes from observation protocols (categories of risky play, social interaction, behavioral scenarios). The following variables were included in the regression model: the overall risk literacy index as the dependent variable, as well as pedagogical conditions (scaffolding, dialogical discussion of risk, joint rule formation) as predictors. The age of the children was considered as a control variable.

All scores were converted into a unified scoring system. The presence of missing values, anomalies, and

incorrectly entered data was checked. In addition, cases with incomplete information (less than half of the indicators) were excluded from the analysis.

Given the use of different types of scales (4-point observation scale and 5-point Likert-type scale in the teacher questionnaire), a standardization procedure was carried out before data integration. All indicators were converted into z-scores in order to ensure their comparability and avoid the dominance of variables with a wider range of values. At the same time, differential weighting of risk literacy components was not used. All eight basic indicators were considered as equivalent and included in the integral index with the same weight. Teacher questionnaire data were used as an additional source of validation of the results, and not as a direct component of the integral indicator. This approach made it possible to ensure methodological transparency and reduce the risk of artificially strengthening individual dimensions.

Next, the internal structure of the indicators was checked. This involved assessing theinternal consistency of the indicators

For the four blocks of the model (cognitive, emotional-volitional, behavioral, social), internal consistency coefficients (Cronbach's α) were calculated. Expectation: $\alpha \geq 0.70$ (acceptable for behavioral measurements in preschool age). The method of correlation analysis was used for the four blocks of the models.

Correlations between cognitive and behavioral indicators (expected relationship with self-stopping and prediction of consequences) were analyzed separately; between emotional regulation and social interaction. In addition, the primary factor grouping of indicators was carried out. Exploratory Factor Analysis (EFA) was applied - the method of principal components with varimax rotation.

Comparative analysis of behavioral manifestations was also important. In particular, based on ANOVA/ Kruskal–Wallis, it was checked whether the levels of indicators differ depending on the type of game (free, mobile, plot-role-playing, constructive) the presence/ absence of a risk element, etc.

The connections between risk literacy and self-regulation were assessed on the basis of correlations between the general index of risk literacy and the results of EF tests ("Stop–Start", "Color rules", "Repeat the path"). In addition, individual and group profiles of risk literacy were formed. For this, cluster analysis (k-means) was used to identify typical profiles of children.

Data collection was conducted over a period of approximately 5 weeks. Observations were carried out by trained researchers/educators who were previously instructed in the use of the checklist and protocol. To ensure the reliability of behavioral observations, a subset of observations (approximately 20%) was independently coded by two raters. Inter-rater agreement was assessed using Cohen's kappa, which indicated acceptable reliability ($\kappa \approx 0.70–0.80$).

Ethical considerations

The research was conducted in compliance with basic modern ethical standards, in accordance with Ukrainian legislation and recommendations of the Ministry of Education and Science of Ukraine. In addition, the study was conducted in compliance with international ethical standards recommended by the European Early Childhood Education Research Association (EECERA), APA Ethical Principles.

Children's participation in the study was completely voluntary. Before the study began, parents or legal guardians were provided with written information about the purpose and objectives of the study and a description of all procedures (observation, game tasks, behavioral assessment).

Only children for whom written informed consent was obtained were included in the sample. The study procedures did not involve any artificial creation of dangerous situations. Observation was conducted exclusively in a natural environment of free play. Educators and researchers ensured safety and the absence of hidden dangers in the play environment. They also provided immediate intervention in case of potential danger. The study does not involve the disclosure of personal information. The data were collected anonymously. All collected data were coded with unique identifiers. No personal information about children was collected or stored in an open form.

Children's age was included as a control variable in further analyses. It was considered in correlation and regression models to test whether the identified relationships between risk literacy components and executive functions persisted regardless of age differences.

Results and Discussion

Results

The study of 8 indicators of risk literacy in a sample of 269 children showed that the system of this concept is multidimensional and consists of 4 integrated components: cognitive, emotional-volitional, behavioral-regulatory and social-communicative.

The cognitive component revealed differences between the two indicators: recognition of risk signals had a relatively high average score (M = 2.39; SD = 0.62).

However, the skills of predicting consequences were lower (*M* = 1.81; *SD* = 0.74). Thus, children more easily identified obvious risks than predict the development of the situation.

The emotional-volitional component was characterized by moderate values (*M* = 2.03; *SD* = 0.71). This can be compared with the average level of ability to regulate emotional stress. The behavioral-regulatory component showed mixed results: internalization of safety rules was relatively high (*M* = 2.31). However, the ability to stop oneself independently had lower values (*M* = 1.92). This can be reconciled with the age-related characteristics of the development of self-control. However, the social-communicative component turned out to be the strongest. Descriptive statistics are presented in Table 3.

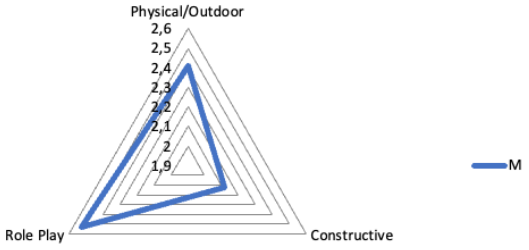
Table 3.
Statistics of risk literacy indicators

Component	Indicator	M	SD
Cognitive	Risk recognition	2.39	0.62
	Consequence prediction	1.81	0.74
Emotional-volitional	Emotional regulation in risk	2.03	0.71
Behavioral-regulatory	Self-restraint	1.92	0.69
	Internalization of rules	2.31	0.65
Social-communicative	Coordination with peers	2.47	0.58
	Help-seeking	2.21	0.67

Determining the levels of indicators in different types of game activities indicated that individual types of games contribute differently to the formation of risk literacy components. Physical/movement games had the highest indicators of the development of behavioral and emotional-volitional components (*M* = 2.41; *SD* = 0.58). Constructive games were aimed at developing cognitive skills predicting consequences and planning actions (*M* = 2.12; *SD* = 0.63). Children regularly demonstrated the ability to assess the stability of structures and the risky consequences of manipulations. Plot-role (sociodramatic) games had the highest indicators of the social-communicative component (*M* = 2.53; *SD* = 0.60). Therefore, different types of games affect different aspects of risk literacy.

The resulting descriptive indicators clearly illustrated the distribution of values for each risk literacy indicator (see Table 3). As can be seen from the table, the highest values were characteristic of the social-communicative component. At the same time, the cognitive component (in particular, predicting consequences) demonstrated lower indicators.

Figure 1.
Radar by game types (mean)



As can be seen from Figure 1, different types of play activities had a differentiated impact on risk literacy components. Mobile games were more associated with the development of behavioral and emotional-volitional aspects, while constructive games contributed to the formation of cognitive skills.

Qualitative analysis of observation protocols made it possible to identify 3 behavioral patterns that indicated the mechanisms of risk literacy formation in the game. Preliminary checking of the situation is important. Children systematically examined objects, structures or the environment before acting they touched the structures, checked their stability. Some asked: "Will this not fall?". Such behavior indicated the initial forms of predicting consequences within the framework of games.

Joint self-regulation with peers (peer co-regulation) also played an important role. In plot-role-playing and mobile games, children coordinated actions, warned each other about possible danger. Children said: "Let's hold together", "You stand here, and I'm here". This reflected the development of the socio-communicative component of risk literacy.

Besides, the coordination of risk with an adult was vital. In difficult or uncertain situations, children turned to the teacher for clarification or permission: "Can I go higher?", "Is it okay if I climb here?" Such behavior indicated reliance on an adult as a source of emotional stabilization.

The study found impacts between pedagogical conditions (based on questionnaire scales and observation protocol coding) and levels of risk literacy in 269 children. Strong positive correlations are evident between: indicators of adult scaffolding and the general index of risk literacy (r = .41, p < .001); dialogical discussion of risk (r = .38, p < .001); joint formation of

rules in the game (r = .33, p < .001); presence of guided challenges in the environment (r = .29, p < .01). Negative impacts were found between:

hyperopia / rigid prohibitions and cognitive indicators (r = –.27, p < .01), and the general index of risk literacy (r = –.31, p < .001).

Therefore, risk avoidance in educational practice reduces the child's ability to learn safe behavior. The regression model indicated that three pedagogical conditions statistically significantly predicted the overall level of risk literacy: Adult scaffolding - β = .28, p < .001; Dialogical discussion of risk - β = .22, p < .01; Shared rule-making - β = .17, p = .02 In this way, the model explained 34% of the variance (R^2 = .34). This is a high indicator for behavioral changes in preschool age.

Different groups of children were analyzed depending on whether the educators used risk-based education strategies in daily play (risk-questioning, planning, rules, reflection, creating challenges).

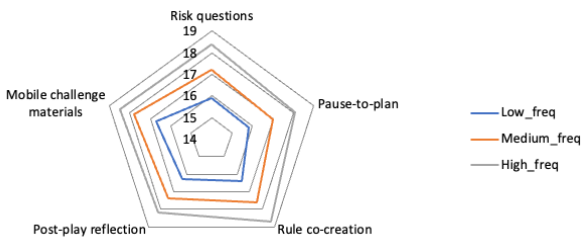
In groups where the strategies were used regularly (3+ times a week), the following was noticeable: a higher overall index of risk literacy (M = 18.9; SD = 3.4)

The strongest effects were demonstrated by: risk-questioning during play ("what could happen?"), which was aimed at increasing cognitive indicators, d = 0.52. The strategy "pause-to-plan before performing a complex action", which was aimed at improving behavioral self-regulation d = 0.48. Hence, Figures 2-3 show the average risk literacy scores of children depending on how often teachers used the corresponding strategies (risk-question, pause-for-plan, rule-making, post-game reflection, mobile materials-challenges). The scores are presented in two generalized categories – high and low frequency of strategy use. They are determined based on the analysis of observation protocols and pedagogical assessments.

Figures 2-3 show that higher levels of risk literacy were associated with more regular use of risk-oriented education strategies.

Figure 2.

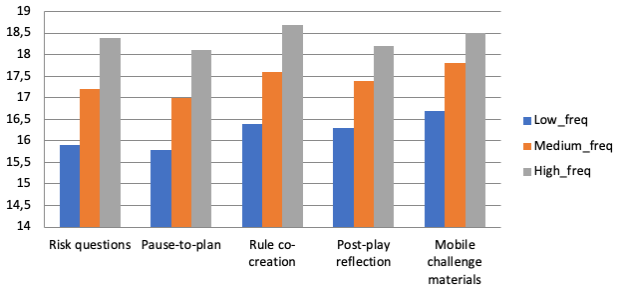
Radar: Frequency Levels



Note: Cognitive (blue), Emotional (green), Behavioral (orange)

Figure 3.

Mean Scores by Frequency Level



Figures 2–3 demonstrate a clear relationship between the frequency of use of pedagogical strategies and the level of risk literacy. Higher rates were observed in groups where risk-based learning strategies were systematically applied.

The study determined which indicators are sensitive and valid for assessing risk literacy. For this purpose, the following were conducted: analysis of internal consistency of scales (Cronbach's α), correlation analysis between indicators, factor analysis and comparison of indicators in the game.

The internal consistency of eight indicators showed a sufficient level of reliability: α = .81 for the general scale (8 indicators); by blocks: cognitive – α = .73; emotional-volitional – α = .70; behavioural – α = .78; social – α = .75. Thus, the indicators agreed well with each other and measured a single construct – risk literacy.

Exploratory Factor Analysis indicated a four-component model that explained 62% of the variance. The indicators were divided into factors as in the theoretical model:

Factor 1 (cognitive): risk recognition (loading = .78); prediction of consequences (.72).

Factor 2 (emotional-volitional): emotional regulation (.69); tolerance for uncertainty (.66).

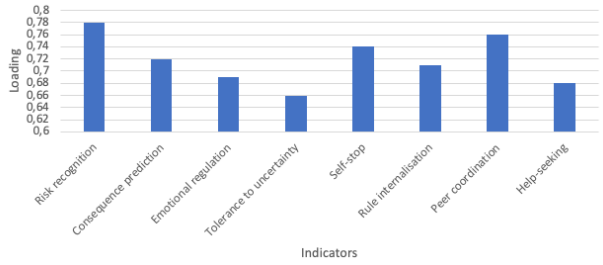
Factor 3 (behavioral): self-stopping (.74); internalization of rules (.71).

Factor 4 (social): coordination with peers (.76); seeking help (.68).

At the same time, no indicator had cross-loadings > .40. Thus, this indicated the stability of the structure. In addition, the correlations of indicators with the frequency of use of pedagogical strategies showed: the most sensitive indicators: prediction of consequences (r = .42, p < .001); self-stopping (r = .39, p < .001); coordination with peers (r = .36, p < .01) These indicators determined the change in the child's behavior in the "managed risk" environment. In addition, a comparison of indicators in different types

of play (physical, constructive, role-playing) showed that cognitive indicators vary most in constructive play (ΔM = 0.61); behavioral indicators - in physical play (ΔM = 0.54); social indicators - in story-role-playing play (ΔM = 0.48) (See Figure 4).

Figure 4.
Factor loadings of main indicators



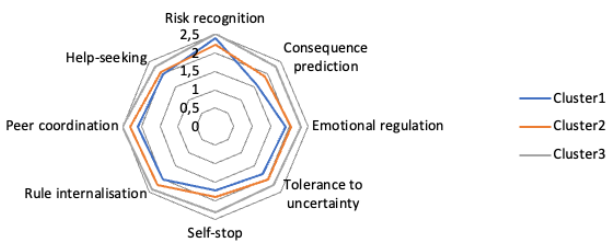
This confirmed their contextual sensitivity. Thus, the most informative indicators of risk literacy are: 1. predicting consequences; 2. self-stopping; 3. coordination with peers, since they have the highest factor loadings and the strongest connection with pedagogical conditions. In addition, cluster analysis (k-means) conducted for 8 indicators of risk literacy allowed us to record three typical profiles of children. The optimal number of clusters (k = 3) was determined based on the Elbow method.

Cluster 1 concerned "Cautious Observers" (34%). These children had the following characteristics: 1. high risk recognition indicators; 2. low ability to predict consequences; 3. weaker self-stopping indicators; 4. tendency to avoid difficult situations.

Cluster 2 concerned "Emerging Regulators" (41%). These children had average indicators in all four components; stable emotional regulation; gradual formation of rules of behavior; improved ability to cooperate with peers. This is the most numerous group with "growing" risk literacy.

Cluster 3 concerned "Competent Risk Navigators" (25%). These children had high cognitive indicators (especially prediction of consequences); developed behavioral self-regulation; and strong social and communicative skills (coordination, asking for help) (See Figure 5).

Figure 5.
Radar chart of cluster profiles



Thus, these profiles indicated the heterogeneity of the development of risk literacy and empirically supported its four-component structure. As shown in Figure 5, cluster profiles differed significantly in the structure of risk literacy components, which confirmed the heterogeneity of the development of this competence in preschool age.

Additional analysis showed the presence of age differences in the formation of risk literacy components. Older children (5–6 years old) demonstrated higher indicators in the cognitive and behavioral components compared to younger children (3–4 years old). This was especially evident in the ability to predict consequences and self-stop. At the same time, risk recognition indicators were relatively stable in different age groups, which indicated an earlier formation of this component. Thus, the results confirmed that the development of risk literacy had age dynamics and was not homogeneous within the preschool period.

Discussion

The results recognized that risk literacy is a multidimensional phenomenon consisting of cognitive, emotional-volitional, behavioral, and social-communicative components. This system is generally consistent with the results of studies that examined the role of risk-taking in the development of self-regulation and social interaction. In addition, Spencer et al. (2021) found that educators assessed children's ability to identify risks based on their cognitive understanding of dangers and emotional control skills. The results also supported this thesis. In particular, in the study by Nikiforidou et al. (2012), children found it easier to recognize risks than to predict their consequences. These data are consistent with the findings of Spencer et al. (2021) that adult involvement helps to "transform" risk recognition into understanding.

The observed discrepancy between the ability to recognize risk and the ability to stop behavior can be explained from the perspective of the development of executive functions in preschool age. Risk recognition was predominantly a cognitive process that was formed earlier, while self-stopping was associated with inhibitory control and self-regulation that developed gradually.

In the context of cultural-historical theory (Pressley & Roehrig, 2014), this can also be interpreted as a gap between the internalization of rules and their actual behavioral application. The child could be aware of the rule or risk but did not yet have sufficient mechanisms of voluntary regulation to implement it in action. In addition, emotional arousal in a game situation could temporarily reduce behavioral control, which is consistent with the views of researchers about the age-related characteristics of the development of

self-regulation (Ibrahim et al., 2018).

High scores on the social-communicative component are also consistent with Szpunar et al. (2023), who emphasized the importance of the idea of cooperative risky experiences. These authors pointed out that interaction between children and discussion of risky situations allows for the development of social competence (Schürer et al., 2025; Szpunar et al., 2023).

In addition, the data obtained indicate that different types of play activities are aimed at developing different aspects of risk literacy. In particular, active games develop behavioral and emotional-volitional aspects, while constructive games are aimed at cognitive aspects. At the same time, role-playing games are aimed at developing social aspects. These results are comparable to other studies that have shown that risk games stimulated independent testing of boundaries and shaped behavioral regulation. In addition, Zhou et al. (2019) indicated that the assimilation of safety rules in everyday situations depended on the activity. At the same time, different game scenarios elicited different types of behavioral responses. The results obtained (in particular, differences in ΔM in the content of indicators between games) confirmed these patterns.

The study also aimed to identify the main pedagogical conditions that promote the development of risk literacy. It was determined that adults are facilitators of risk literacy. The strongest predictors were: scaffolding (β = .28), dialogic discussion of risk (β = .22), and joint rule creation (β = .17). These results are consistent with Szpunar et al. (2023), who indicated that professional training of teachers increased their tolerance for risky play and increased the frequency of using dialogic strategies. This finding is confirmed in other studies, which indicate that adults should "structure but not control" risky play. The data also indicated a higher overall risk literacy index in children whose teachers used risk questions, pause-to-plan, and reflection ≥3 times per week. These data are also consistent with international studies (Nurseitova et al., 2024; Sak et al., 2025). In particular, Termenzhy (2024) found that a personalized, needs-based approach significantly increased students' cognitive engagement and self-regulation. The study by Türen and Bağçeli Kahraman (2024) also indicated that parents' digital competence and risk literacy influence the extent to which children are prone to digital game addiction. This confirmed our thesis about the importance of adults as risk regulators. This has also been discussed by other researchers who have studied the importance of adults in digital environments (Aslan & Shiong, 2023; Bang et al., 2022; Maksymchuk et al., 2019a; Pazarcikci & Ağrali, 2024).

The study indicated that the most informative indicators were consequence prediction (r = .42), self-control (r = .39), and coordination with peers (r = .36). These indicators are sensitive to pedagogical conditions and the game organization system. These data partially agree with Wang et al. (2021), who indicated that family experience influenced behavioral regulation and children's ability to act in potentially dangerous situations. The data obtained can be compared with the meta-analysis by Zheng et al. (2022) and Rech et al. (2024), in which the authors indicated that self-regulation and adaptive behavior skills are most sensitive to interventions that focus on individual differences. The resulting clustering, in particular, three profiles of risk literacy, confirmed the heterogeneity of this construct. Thus, the study has practical and scientific value. In particular, the work proposed and empirically confirmed the concept of "risk literacy", which acts as a multidimensional system. At the same time, the model showed the mechanism of forming safe behavior based on managed risk in the game. This combined the socio-cultural logic of development (game as a leading activity, internalization of rules and self-regulation) and the ecological perspective (environment as a system of opportunities/constraints). Thus, the study proposed the following balance "challenge–safety" as a basic pedagogical principle.

The results obtained are consistent with the notion of uneven development of executive functions in preschool age (Karabon & Steiner, 2020). Age acted as an important moderator of the formation of risk literacy, since it was at the age of 5–6 that significant development of inhibitory control and voluntary regulation of behavior occurred.

Despite the results, the study has several limitations. In particular, it is worth highlighting the observational design. In particular, the study did not involve experimental division of children into groups, therefore, the identified links between pedagogical conditions and risk literacy should be interpreted as impacts, and not as strict causal effects. The sample includes children from preschool institutions in the city of Kyiv. Accordingly, urban or rural conditions were not considered in terms of the level of "safety". Accordingly, subsequent studies should be conducted in different cities and villages and compare the impact of sociocultural conditions on the formation of risk literacy. Also, in the future, broader experimental studies should be conducted. Although the study used factor analysis (EFA) to test the model structure, structural modeling (SEM) was not conducted. This is due to the primary nature of the empirical validation of the proposed model. Further research may be aimed at using SEM to more deeply test the causal relationships between the risk literacy components and assess the quality of the model (model fit indices). Another limitation concerns the use of teacher-reported data, which may be subject

to social desirability bias, particularly in evaluating pedagogical practices related to risk.

Conclusions

The study made it possible to determine the structure, mechanisms and pedagogical conditions for the formation of risk literacy in preschool children. It is indicated that risk literacy is a multidimensional system consisting of cognitive, emotional-volitional, behavioral-regulatory, and socio-communicative components. Such a system reflected the synthesis of the ability to recognize potentially dangerous situations, emotionally stabilize in conditions of uncertainty, regulate one's own actions, and interact with others. It is indicated that different types of games unevenly contributed to the formation of risk literacy components. Outdoor games influenced the formation of behavioral self-regulation and emotional endurance, constructive games - the development of cognitive abilities, plot-role-playing games - the improvement of social and communicative skills. Hence, the game is an environment for pedagogical support of safe risk.

The key conclusion was that pedagogical conditions modify the levels of risk literacy. Strategies that are based on dialogical discussion of risk and joint formulation of rules are significant factors in the overall level of risk literacy. On the other hand, excessive prohibitions and hyper-care reduced the opportunities for the formation of self-regulation and adequate risk assessment. Hence, the risk literacy is an important component of a preschooler's readiness for safe interaction with the world. Its development requires balanced conditions, in particular, freedom of play, pedagogical support and moderate challenges. The proposed model and validated indicators can serve as the basis for further comparative, longitudinal and intervention studies. Thus, the results of the study highlighted the need to move from a model of risk avoidance to a model of its pedagogically guided use as a development resource.

AI Disclosure Statement

During the preparation of the manuscript, the authors used AI tools exclusively for linguistic editing and stylistic polishing of the text. AI was not used to generate scientific ideas, analyze data, interpret results, or formulate conclusions. The authors fully reviewed and are responsible for the final content of the article.

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Appendixes

Appendix 1. Observation protocol "Risky Play Observation Sheet"

Categories of risky play

1. Play at height
2. Play at high speed
3. Play with dangerous tools
4. Play with elements of uncertainty
5. Rough mobile interaction
6. Remoteness/independent action without an adult
7. Combination risk scenarios

For each episode, the following is recorded:

1. duration (sec.)
2. context (type of game)
3. adult participation (0 – none, 1 – observation, 2 – scaffolding)
4. risk literacy indicators (8 scales)
5. social interaction (solitary / pair / group)
6. challenge level (low / medium / high)
7. presence of risky success (yes/no)
8. presence of risky error (yes/no)

Appendix 2. Scale of pedagogical conditions (score from 1 to 5)

1. I discuss possible risks with children before starting the game.
2. I pose "risk questions" ("What could happen?", "What is the plan?").
3. I use scaffolding, not prohibitions.
4. I create conditions for guided challenges (height, speed, structures).
5. I allow children to negotiate rules on their own.
6. I observe, without interrupting the game without urgent need.
7. I discuss mistakes after the game ("What could be done differently?").
8. I reduce the number of direct prohibitions in the game.

Calculation:

General index of pedagogical support for risk: M from 1 to 5.

Subscales: scaffolding, dialogue, rules, challenges.

Appendix 3. Tasks for executive functions (EF Tasks)

1. "Start and star" (inhibition)
   Instruction: move to the music, freeze when the music stops.
   Indicators: number of correct stops / impulsive movements.
2. "Color rules" (cognitive flexibility)
   Instruction: "If the card is blue, run; if it is red, crouch."
   Indicators: number of correct reactions/switches.
3. "Follow the path" (working memory)
   The child repeats a route of 3–6 steps.
   Indicators: maximum length of the sequence reproduced.

Appendix 4. Questionnaire for teachers "Risk Beliefs & Practices"

Examples of statements (5-point scale):

1. I believe that risky play is important for development.
2. I feel confident allowing children to take risks in play.
3. I find it difficult not to intervene in risky situations.
4. I tend to prohibit more often than to allow.
5. I believe that risk can be turned into a learning situation.