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Influences of Interaction Styles and Its Relation to Bloom's Taxonomy on Level 3 Thinking Skills for Children at age 8-9 in Educational Application (Case Studies: Math Subject)

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Abstract

Supporting the development of children's thinking capabilities, educational applications are vital. The mathematical thinking abilities of children ages 8 to 9 are the subject of this study, specifically Level 3 thinking capabilities (C3) according to Bloom's Taxonomy. This study investigated two ways for children to interact with an educational app: entering responses in text boxes (form-filling) and selecting answers using buttons (direct manipulation). These methods were built with a user-centered approach. The goal was to discover the most suited style for improving these skills. The study included 18 youngsters who were tested in three different stages. Processing time, scores, and user preferences were among the data points gathered. Shorter average processing times, higher scores, and greater user preferences across all tests show that the form-filling interaction style is more effective. These results show that children's higher-order thinking skills can be enhanced through the use of personalized interaction styles in educational applications. The findings of this study will help in the creation of better instructional materials for elementary school students.

Keywords: User Experience, Educational Application, Interaction Styles, User-centered Design

I. INTRODUCTION

An educational Application plays a crucial role in the learning process, especially for children aged 8 to 9 years. It not only helps them understand the material but also meets the criteria for understanding and children's thinking abilities in the Application section (or called C3 in Bloom's taxonomy). Students must achieve goals and objectives in the learning process. These goals and objectives can be measured using Bloom's taxonomy. In Bloom's taxonomy, there is one level, namely the third level, called application. At this level, application is intended as the ability to apply information in real situations or the ability to use concepts in practice or new situations [1].

In Bloom's Taxonomy cognitive domain, from the teaching staff (teachers) questioned, it is known that the sub-domain used in the learning process to measure the thinking ability of children aged 8 to 9 years, namely the Application or C3 level. According to the teacher, one of the materials that children need help understanding or

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applying their C3 thinking skills is math subject. Based on the needs and criteria of children's thinking abilities known above, the main factor that must be considered in designing educational applications is selecting the application's interaction framework (interaction styles). An interaction framework is how users interact with the system/computer [2].

The interaction style in an educational application is one of the things that must be considered because not all levels of education use the same interaction style. The importance of choosing the right interaction style in educational applications is that in addition to helping children understand what material is being learned, they can also achieve the thinking ability that is being measured. In choosing the right interaction style for various thinking abilities, several examples of interaction styles are used in several educational applications, namely, form-filling and direct manipulation interaction styles. Both interaction styles are used as a means to measure the achievement of C3 thinking ability in Mathematics because the form of thinking ability measurement questions for C3 is usually in the form of essay questions with narrative-based questions, which require students to be able to apply the concept of comparison and require students to choose certain concepts to calculate and connect between two or more information [3]. With form filling, students do this in a way that is almost the same as in direct learning: working on narrative-based questions and filling them in the answer sheet provided. For the direct manipulation style, students work on the problem through multiple-choice problems and interactive applications (such as animation, role-playing, and games).

In addition to the interaction style, making an application is no less critical, especially for an educational application that must know what features children need. One method of making applications that focus on what is required by its users is User-centered Design, a method for creating experiences or experiences that are suitable for users [4]. A user-centered design that prioritizes what users need can help find out what children need as users when making these educational applications. The study used the a Quality in Use Integrated Measurement (QUIM) framework, by Ahmed Seffah [5], to assess how well the interaction styles worked. Meanwhile, to measure the success of children's C3 thinking skills by using measurements in Bloom's taxonomy, namely whether with the help of educational applications made with these interaction styles, children can solve a problem using standards/procedures they already know [6].

While earlier studies have widely used UCD and interaction testing in educational applications, our research focuses primarily on how different interaction styles affect Level 3 (C3) thinking skills in children aged 8 to 9. Unlike previous research, this study compares form-filling vs. direct manipulation within the context of Bloom's Taxonomy, thereby filling a gap in understanding how interaction styles affect higher-order cognitive processes [11,12]. Problem Formulation and Recommendations: This research will provide valuable insights into which interaction style is more suitable for use in educational applications, thereby supplementing the learning process and helping children achieve their thinking ability goals.

A. Topic and its Limitation

Based on the above background, to determine which interaction style is more helpful in achieving children's C3-level thinking skills, educational applications with two different interaction styles need to be made to determine which interactions are more suitable and help children achieve C3 achievement criteria. The selected interactive styles, namely direct Manipulation and form filling, are applied using a user-centered design that can determine what children need.

The limitations of the research scope are as follows:

- The object of Research is elementary school children aged 8 to 9 years.
- The subject chosen for the content of the educational application is math.
- The C3-level thinking skill competency chosen is the ability to understand, translate, or apply what has been taught from narrative-based problems.
- The educational application platform is made using an Android-based mobile or smartphone.
- The user-centered design method is rigorously applied to design and determine the functions and features of the application, ensuring that the needs of the children are at the forefront of the research.
- There are two interaction styles compared, Direct Manipulation and Form-Filling.

B. Goals

The primary goal of this Research is to determine which interaction style is suitable for 8 to 9-year-olds and can help them achieve their C3-level thinking criteria.

II. LITERATURE REVIEW

A. User Experience

User Experience (UX) is a feeling, thought, sensation, and action that results from carrying out an activity or activity [7]. In human-computer interaction (HCI), UX measures how good or bad an interactive product is by examining how comfortable, easy, or fast it is to achieve the goals people want when using the interactive product.

B. Interaction Styles

Interaction Style is a way for people to interact with interactive products so that the product and the person communicate with each other [8]. The interaction styles used in this Research are Direct Manipulation and Form-Filling. Direct Manipulation is an interaction style where people interact directly with objects on the screen and insert their input directly into the object. For example, directly touching the back button on a smartphone application or performing a drag-and-drop command on the main computer screen [8]. Form-filling is an interaction style where a system or application asks its users to fill in a form provided by the system by giving easy-to-understand instructions [8].

C. User Persona

User Persona is a combination of detailed archetypes of users that represent the behavior, attitudes, abilities, goals, and motivations of different groups observed and identified during the research period[9]. In designing a framework or prototype, the user persona becomes input and reference when determining a need for or improvement of a feature.

D. User-Centered Design

User-centered design is a method of designing a system by involving its users. At a high level of involvement, users will enter and participate in the design stage of the system. At a low level of involvement, users will only be consulted about their needs and later supervised during the usability testing stage [10].

E. Quality in Use of Integrated Measurement

Quality in Use of Integrated Measurement (QUIM) is an in-use measurement model that combines the ISO 9241 and ISO 9126 standards into a single hierarchical model. This model has ten factors: Efficiency, Effectiveness, Satisfaction, Learnability, Productivity, Safety, Trustfulness, Accessibility, Usefulness, and Universality [12].

III. RESEARCH METHOD

The experimental methods should be presented clearly and completely, in every detail, to facilitate reproducibility by other scientists.

The user-centered design (UCD) method is used to make an application that tests children's interaction styles. By using UCD, it will get output in the form of user personas, which will be used to create the design and function of the application. Features and designs that are simple and easy to understand can help children use the application, which can later help test the appropriate application style. After creating user personas and getting user needs from the personas obtained, a prototype of the testing application is made based on user needs, and the algorithm is implemented so that the features can function correctly. The research involved 18 children aged 8–9 years from grade 3 at SD Negeri 2 Rancamaya. Respondents were selected based on their ability to read and understand instructions, familiarity with smartphones, and exposure to internet use.

The app was tested three times, each with different sets of questions to compare the interaction styles. The order of testing and the questions entered will always be different in each test. Also, during the test, the child will be supervised and observed, and later, the observation data is entered into the form (containing the duration of work, reading behavior, how to solve the problem, and the number of correct) that has been prepared. After completing the test, the child will be asked about the application feedback and preferred interaction style.

A. Data Collection

The initial stage of this study was to conduct questionnaires and interviews with all 3rd-grade children of SD Negeri 2 Rancamaya regarding their use of smartphones or other technological tools and their habits in using these tools. After conducting questionnaires and interviews, observations were also made of children using smartphones to determine their behavior and skills in using smartphones.

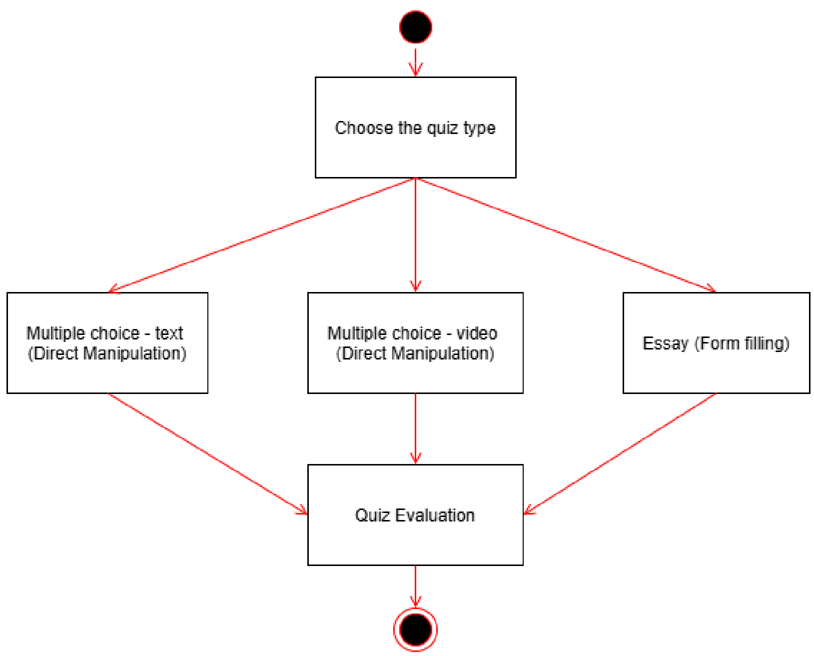

Fig. 1. Activity Diagram of the testing app

B. User Requirement Analysis

The questionnaire was conducted and created using Google Forms. The questions were about how often children interact with smartphones or the internet, their color preferences, and the appearance of an application in general. In addition to Interviews, observations were also made, where children were given instructions to do something in the application to determine how accustomed they were to using smartphones.

TABLE I. TASK ANALYSIS

No	Task	Sub Task	Users	Goals	System
1	Working on Problems (text)	Reading the problem and choosing on answer	Children	User choose the answer and get the result	Steps: 1) Select start 2) Select the multiple chioce – text menu 3) Get an evaluation of how many answers are correct
2	Working on Problems (videos)	Watching the problem and choosing on answer	Children	User choose the answer and get the result	Steps: 1) Select start 2) Select the multiple chioce – video menu 3) Get an evaluation of how many answers are correct
3	Working on essay	Reading the problem and input the answer	Children	User fill and input the answer and get the result	Steps: 1) Select start 2) Select the essay menu 3) Get an evaluation of how many answers are correct

C. Designing Prototype

The design was based on the questionnaire results regarding color selection and the user requirements obtained from the personas and interviews. Fig. 2 is a Prototype design of the testing application.

D. Testing Planning

Testing is done by making users or children work on problems in two ways: with a direct manipulation interaction style, where children work on multiple-choice questions and directly choose the answers that have been provided, and with a form-filling interaction style, where children work on essay-shaped story problems by writing/typing the answers they have obtained into the answer column in the application.

After the child uses and works on the questions in the application, the child will then be asked ten questions based on the ten QUIM factors consisting of two choices, namely yes or no, to assess the performance of the application, as well as two questions regarding which interaction style preference they prefer.

The form of the questions is as follows:

- Does the app deliver the questions well?
- Is this app suitable for learning?
- When you finished using the app, were you satisfied/enjoyed the app? (If answered no, ask why)
- Is the app easy to use?
- Can this app help you get better at math?
- Do you feel safe and comfortable when using this app?
- Do you feel happy when you can/understand how to use this app?
- Did you feel any difficulties while using this app?
- Has this app provided the questions correctly?

- Can your friends use/understand this app?

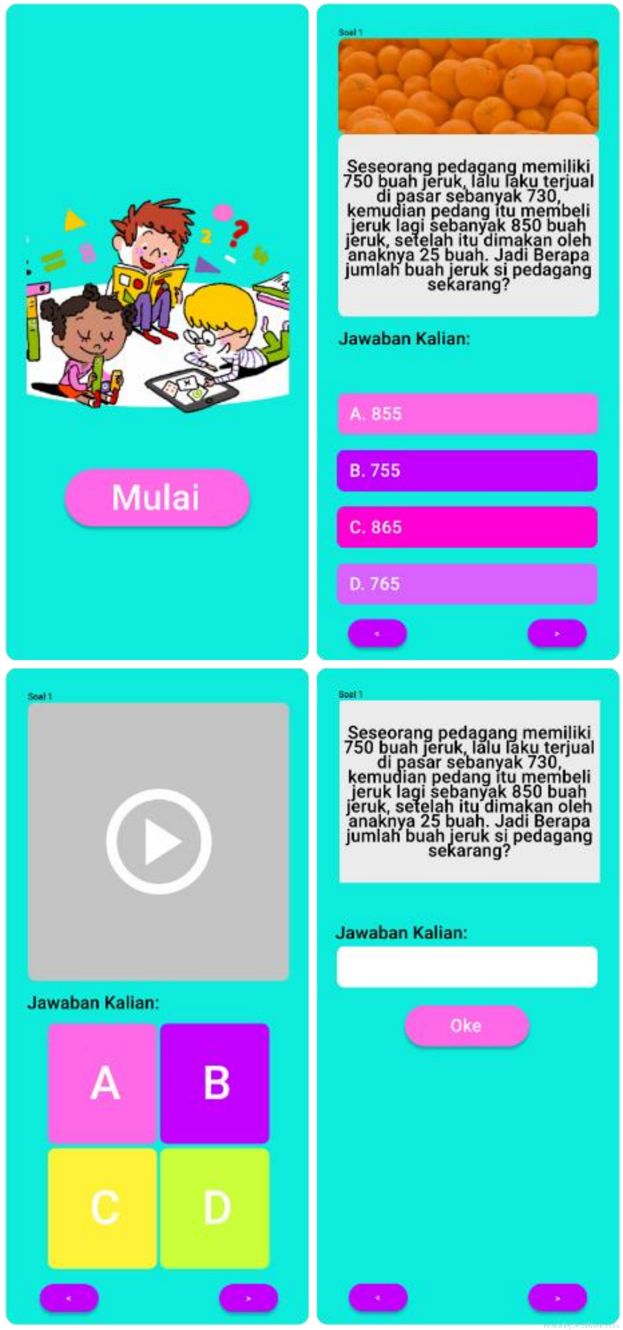

Fig. 2. Prototype design of the testing app

E. Design and Algorithm Implementation

The design from Fig. 2 has been given functionality so that it can function according to what is needed. The functions are given and created using Unity Engine version 2020.3.25f1. Fig. 3 shows a Design with the implemented algorithm.

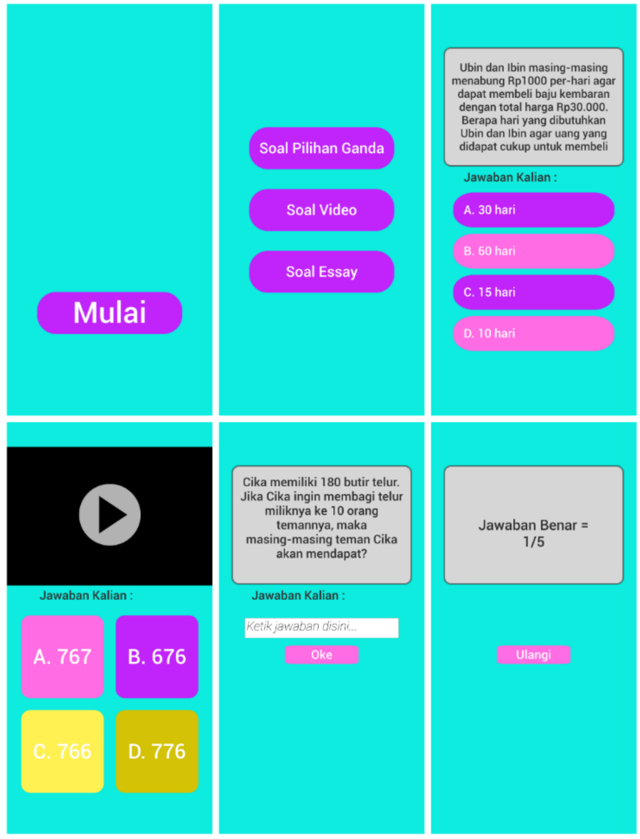

Fig. 3. Design with the implemented algorithm

TABLE II. TABLE TYPE STYLES

Profile	• Children of age 8-to-9 years old • Male and Female • Grade 3 and 4 of Indonesian elementary school.
Skills	• Can read, understand, and speak Bahasa. • Has been exposed to the internet • Quick to understand and learn how to use a smartphone • Able to read, understand, or execute commands/instructions in the operation of smartphone applications
Behavior	• Ask for help if you encounter a problem • Short attention span if with friends • Repeats from the beginning if they do not understand the command or make a mistake.
Influence	• The geographic location that is far from access to the internet or smartphone • Limited usage of the internet by parents
Social	• Daily activities consisted of studying and playing with friends • Likes to do an activity with friends after school.
Needs	• Can understand mathematics problems at the C3 level, which is a narrative-based problem • Can read and understand commands from what they read. • Can use and type on the keyboard. • Can understand the steps of an application based on what they've commanded.

TABLE III. USER NEEDS AND REQUIREMENTS

Needs	Application Requirement
1. Achieve level C3 or Application in math subjects in Bloom's taxonomy measurement. 2. Understand instructions in both oral and written form 3. Able to understand and operate new applications quickly and without help or instruction from others.	1. The question content of the quiz app should be suitable for testing and measuring the achievement level of C3 in Bloom's taxonomy measurement. 2. The application has questions in oral (video) or written (text) forms. 3. The menu design and appearance of the application are to the point and easy to operate.

IV. RESULTS AND DISCUSSION

A. *Persona*

The personas in the table above are obtained from questionnaires guided by teaching staff, direct face-to-face interviews, and observation of behavior and habits in using smartphones. The user must be based on the above personas, as Table III shows. These needs were chosen based on the results of the observation; these three needs are the most important things to be tested because, from the results of the persona obtained, there are still some children who are not proficient enough / not yet able to fulfill the three needs in the table above.

B. *Testing*

The test was conducted three times. In the first test, the order of work is that children work on questions with a Direct Manipulation interaction style first (Working on multiple-choice test questions first, followed by multiple-choice video questions) and then on questions with a form-filling interaction style (Essay-type questions where children must fill in their answers to the form provided in the application).

The first test was conducted on 18 students in grade 3 of SD Negeri 3 Rancamaya. The second test was conducted by changing the content of the application questions and the order of work. Children worked on questions with the Form Filling interaction style first, followed by Direct Manipulation type questions (multiple-choice test, then multiple-choice video). The number of children tested is still the same as the previous test, which was 18 children. The third and final test process is still the same as the previous test, which tested 18 children; the application questions are changed, and the order of working on them is back to working on Direct Manipulation questions (this time, the video multiple choice questions first) then followed by Form Filling questions (where after working on the essay, the last order is working on multiple choice test questions).

From the three tests conducted, which can be seen in the diagrams (Fig. 4- Fig. 6), it can be seen and compared that of the two interaction styles tested, the questions with the form-filling interaction style have a shorter average processing time, a more significant average score (2 out of 3 tests) and are more favored by children (three tests always get a percentage of more than 50%) compared to the Direct Manipulation interaction style questions.

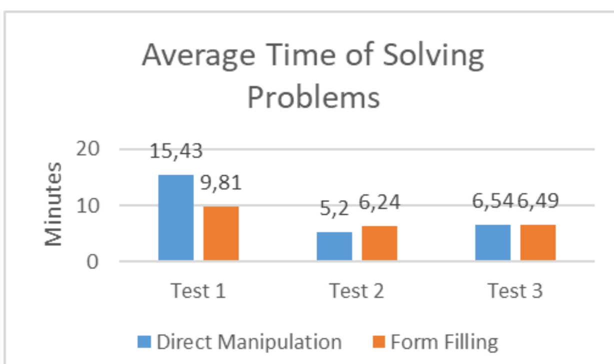

Fig. 4. Average Time of Solving Problems

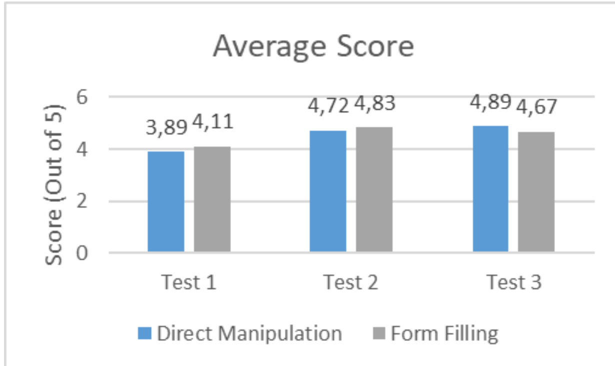

Fig. 5. Average Score

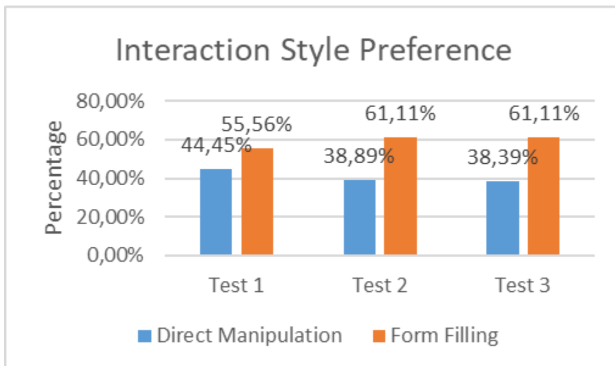

Fig. 6. Interaction Style Preference

The first test, problems with the Direct Manipulation interaction style have a longer average time (15.4 minutes) compared to Form Filling (9.8 minutes), where both have a difference of almost five minutes. Problems with the Form Filling interaction style had a higher average (4.1) than those with Direct Manipulation (3.8). For preferences, the Form Filling interaction style was the favorite of 18 children tested with a more than 50% percentage. While Direct Manipulation, which is a combination of text & video question preferences, got just over 40% of the remaining percentage.

TABLE IV. QUIM ANSWER PERCENTAGE

QUIM Answer Percentage (Questions 1-10) Test 1	97.22%
QUIM Answer Percentage (Question 1-10) Test 2	100%
QUIM Answer Percentage (Questions 1-10) Test 3	100%

In the second test, the average processing time decreased compared to the average of the first test, and the Form Filling interaction style question experienced an increase in processing time when compared to the previous test, contrary to the Direct Manipulation interaction style question, which experienced a decrease in average. For the average score, the second test experienced an increase in both interaction styles, and the Form Filling interaction style questions still had a higher average than the Direct Manipulation interaction style questions. In the second test, the preference for Form-filling interaction style questions increased by 10% compared to the results from the first test. Problems with this interaction style were chosen by 61% of children, while questions with the Direct Manipulation interaction style only received 38%. The third and final test process is still the same as the previous test, which tested 18 children; the application questions are changed, and the order of working on them is back to working on Direct Manipulation questions (this time, the video multiple choice questions first) then followed by Form Filling questions (where after working on the essay, the last order is working on multiple choice test questions).

Table IV shows the children's answers after being asked ten measuring questions explained in Chapter III, Testing Planning. In the first test, the percentage of positive answers (yes answers) was 97.22%, and in the second and third tests, it was 100%.

The considerable decrease in time spent solving the problems from the first to the second and third tests, compared to the second to the third (from 15 minutes to 5 minutes on average for Direct Manipulation and 9 minutes to 6 minutes for form-filling), was influenced by the children's familiarity with operating the application and their familiarity with the tester.

The results show that form-filling interaction styles greatly improve children's ability to apply learnt concepts in new settings, a dimension not previously investigated. This study advances the field by establishing a direct link between interaction patterns and Bloom's C3 level, providing educators and developers with a more targeted approach to building learning apps that promote higher-order thinking

V. Conclusion

The conclusion from the tests that have been carried out and the data generated is that for children aged 8-9 years, an interaction style is obtained that is suitable and supports the learning process and testing of their Bloom's taxonomy C3 level (Application) ability by reading, understanding and then applying the mathematical formula from the problem they read and then filling in the answers in the form that is already available. And the interaction style is form-filling. In all three tests conducted, Children performed better with form-filling. They answered faster, scored higher, and preferred this method over direct manipulation. This interaction style is consistent with Bloom's Taxonomy C3 level, in which children demonstrated an improved capacity to apply acquired concepts in new and practical situations. Unlike previous research, which primarily examines interaction design in general learning environments, this study shows that interaction styles have a direct impact on higher-order cognitive development. Our findings shed new light on interaction design strategies that might be modified to better help children's critical thinking skills.

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