Journal of Contemporary Educational Research, 2024, Volume 8, Issue 11
http://ojs.bbwpublisher.com/index.php/JCER
ISSN Online: 2208-8474
ISSN Print: 2208-8466

A Study on Introducing Logical Symbols with Stories to Improve Critical Thinking with a Comparative Experiment

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Abstract: Critical thinking is becoming more and more important in modern society. Logical thinking is one of the core abilities of critical thinking. However, teaching logic to children faces some challenges especially when introducing logical symbols such as the implication symbol. Using stories to introduce logical symbols will address this problem and improve critical thinking.

Keywords: Logical symbol; Critical thinking; Stories; Education

Online publication: November 27, 2024

1. Introduction

Critical thinking is an essential skill that equips children with the ability to analyze, reason, and evaluate information in a logical manner [1]. This article explores how teaching logical symbols through storytelling can enhance the understanding of logic, ultimately fostering critical thinking. Logical symbols, while crucial in formal reasoning, are often challenging to grasp. Introducing them through engaging stories provides a more accessible and relatable learning experience. We focus on the implication symbol (→) particularly and show how stories can contextualize its meaning. Experiments show that teaching children logical symbols with stories significantly improves their understanding of logical symbols in selection tasks. This approach not only clarifies the role of logic in critical thinking but also improves children's overall reasoning skills.

2. Logical thinking and critical thinking

Critical thinking is the process of analyzing, evaluating, and synthesizing information to make reasoned judgments. It involves the ability to think independently, to reflect on the validity of arguments, and to avoid being swayed by emotional appeals or fallacious reasoning. In the modern world, where children are bombarded with vast amounts of information, it is crucial for them to learn how to differentiate between

credible information and misinformation [2]. College children, in particular, need to develop critical thinking skills because they are at a stage where they are transitioning from structured learning environments to more independent and self-directed educational experiences. Critical thinking enables children to tackle complex problems, conduct rigorous research, and engage in informed debates. Without critical thinking, children may struggle to make sound decisions and engage in meaningful discourse, or even to contribute effectively in professional and academic contexts in the future.

Logical thinking, sometimes regarded as a synonym of critical thinking, is actually the foundational component of critical thinking [3]. While critical thinking encompasses broader intellectual engagement, logic focuses on the structure and coherence of arguments. Logical thinking allows individuals to break down arguments into their fundamental components, understand the relationships between ideas, and assess whether conclusions are valid based on given premises. It encourages precision and clarity, which are vital in evaluating arguments critically. In critical thinking, logical reasoning ensures that children can follow chains of thought, detect inconsistencies, and avoid cognitive biases. Logical thinking serves as the backbone for constructing valid arguments, distinguishing between valid and invalid inferences, and ultimately arriving at sound conclusions [4].

3. Importance and challenges of logical symbols in teaching logic: Selection task

Logical symbols are a shorthand for expressing logical relationships in a precise, formal manner. They simplify complex statements and allow for the manipulation of arguments in formal proofs and reasoning. However, these symbols are often difficult for children to understand because they are abstract and require an understanding of formal systems of reasoning. For example, the implication symbol (→), representing "if... then," is often misunderstood because it does not always align with everyday uses of "if" and "then." One typical example is the famous Wason selection task [5]. In the Wason selection task, participants typically see four cards, each showing one side with either a number (even or odd) or a letter (vowel or consonant). A common version presents cards showing: 2, 3, A, and D. The rule might be, "If a card shows an even number, then its opposite side must show a vowel." Participants are asked to identify which cards need to be flipped to verify the rule. The logical solution involves flipping the card showing 2 (to check for a vowel) and the card showing D (to check that a consonant is not paired with an even number). However, many participants often choose the card showing 3, showing they are unfamiliar with the implication rule. This task illustrates some cognitive biases in reasoning, emphasizing how people often prioritize confirming evidence over falsifying potential exceptions, it also shows the difficulty of teaching the implication connective.

4. Introducing logical symbols with stories: The implication symbol (→)

One effective way to introduce logical symbols is through storytelling, which can bridge the gap between abstract concepts and concrete understanding. The implication symbol (→) can be particularly challenging for children. A story can be used to demonstrate the nature of implication in a way that makes sense intuitively.

For instance, imagine a story about a kingdom where every knight follows a strict rule: "If the king commands, the knight must obey." This mirrors the implication symbol (if p, then q), where "p" is the king's command, and "q" is the knight's obedience. However, the story might continue to show that if the king does not command, the knight is free to do as he pleases—this helps children understand that the implication does

not require the king to command, but only establishes what happens if he does. The story then goes on to illustrate that just because a knight is in obedience does not mean that the king has given the order. Such a story clarifies that an implication is not bidirectional ($p \rightarrow q$ does not imply $q \rightarrow p$) and helps dispel common misconceptions about the nature of logical implication.

This storytelling method could also include various scenarios that reinforce the relationship between the conditions (p) and their consequences (q). For example, another story might involve a student and a teacher: "If the student completes the assignment (p), then the teacher will grade it (q)." Through these narratives, the abstract concept of implication becomes more relatable, helping children internalize the meaning behind the symbol.

5. How storytelling improves logical thinking: A comparative experiment

We conducted a comparative experiment involving two classes of children from the local community, each comprising 30 students aged 10 to 12 years. Both classes were instructed in a logic course focused on implications for four weeks. The educational methods differed: Class A utilized a storytelling approach, where complex logical concepts were integrated into narrative contexts, while Class B followed a traditional lecture-based format with standard exercises and examples.

After completing the course, both classes participated in the Wason selection task. The assessment consisted of a series of problems that tested their ability to apply logical rules to various scenarios. The results indicated that Class A scored an average of 85%, significantly outperforming Class B, which achieved an average score of 65%.

This discrepancy in outcomes can be attributed to the engagement and cognitive connection fostered by storytelling. By embedding logical principles within narratives, students in Class A were able to visualize scenarios and relate them to real-life situations, enhancing their comprehension and retention of abstract concepts. Conversely, the traditional method may have limited students' ability to connect the material with practical applications, leading to a shallow understanding.

In short, our findings suggest that innovative instructional strategies, such as storytelling, can substantially enhance students' understanding and application of logical reasoning. Indeed, introducing logical symbols through stories has several pedagogical advantages that contribute to the improvement of both logical thinking and critical thinking. The advantages are listed as follows:

First, storytelling engages children on an emotional and cognitive level. By embedding logical concepts within narratives, children are more likely to relate to the material, remember key ideas, and understand abstract symbols. Storytelling also provides a framework in which children can see the real-world applications of logical reasoning, making the learning experience more meaningful.

Second, using stories to explain logical symbols helps reduce cognitive overload. Instead of being confronted with abstract symbols without context, children are first introduced to them through relatable scenarios. This step-by-step approach allows them to gradually build an understanding of logic without being overwhelmed by its formal nature. Stories also naturally provide examples of how logical symbols function in different situations, which reinforces children's ability to apply these concepts in their reasoning.

Third, storytelling fosters deeper engagement with the material, which is critical for developing critical thinking skills. When children are actively engaged with the content, they are more likely to ask questions, challenge assumptions, and apply what they have learned to new contexts. By making logical symbols

more accessible through stories, educators can ensure that children develop a stronger foundation in logical thinking, which is crucial for critical thinking.

Lastly, the storytelling method encourages active learning. As children encounter stories that illustrate logical relationships, they begin to construct their own mental models of how these symbols work. They can then apply these models to analyze and evaluate arguments in various contexts, enhancing their critical thinking capabilities. The ability to break down complex arguments, identify logical structures, and assess the validity of conclusions is at the heart of critical thinking, and introducing logical symbols through stories provides the necessary tools to do so.

6. Potential limitations of storytelling

Admittedly, in the context of utilizing storytelling as a pedagogical method for introducing logical symbols to enhance critical thinking, several limitations will surely emerge. Firstly, this approach inherently relies on exemplifying a specific instance from a broader conceptual category and we are not able to exhaust the list. Consequently, it may inadvertently overlook or exclude category members that are different from the story being presented. This limitation may restrict the breadth of understanding that children develop about logical symbols, as their learning may not encompass the full diversity of logical applications.

Secondly, there remains a cognitive challenge in translating narrative content into abstract concepts. Children may become so immersed in the narrative elements of the story that they struggle to draw connections to the underlying logical principles being taught. This could hinder their ability to transfer learned concepts to novel situations, leading to difficulties in making valid inferences when faced with variations in context. Moreover, sometimes it is hard to find appropriate narratives for children.

Such cognitive biases highlight the necessity for educators to balance engaging storytelling with explicit instruction on logical concepts, ensuring that children can generalize their understanding effectively.

7. Conclusion

The individual's sense of truth needs to be generated in the pursuit and search for truth, and children's philosophy is an inquiry into the meaning of life. Therefore, teaching critical thinking is a vital part of primary education, and logical thinking plays an essential role in this process. However, the abstract nature of logical symbols, particularly the implication symbol (→), presents challenges for children. By introducing these symbols through stories, educators can make logic more relatable and easier to understand. This approach not only improves children's logical reasoning but also their critical thinking skills. Despite its potential limitations, it can still be effectively utilized by educators.

In conclusion, logic education for children is a process of inquiry, dialogue, and thinking, and the introduction of abstract symbols in dialogue through stories can better stimulate children's thinking. Through engaging narratives, children are better equipped to apply logic in their daily lives, making them more effective thinkers, problem-solvers, and decision-makers.

Disclosure statement

The authors declare no conflict of interest.

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