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From Cognition to Evaluation: Enhancing Critical Thinking and Self-Regulation in Science Education Through Makiguchian Pedagogy

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Abstract

The emphasis on multiculturalism and innovation in science education has intensified scholarly interest in diverse pedagogical frameworks. Tsunesaburo Makiguchi (1871-1944) anticipated key social constructivist principles prior to their systematic articulation in Western theory. Central to his educational philosophy is the relationship between the individual and society, conceptualized through cognition (the pursuit of truth), evaluation (subjective meaning-making), and value creation (the foundation for socially mediated learning). This study aims to extend constructivist learning-teaching approaches in science education and bring the value creation (Soka) pedagogy of Makiguchi to the middle school level. Within this framework, the present study examines the effects of the Makiguchian approach on students' critical thinking and self-regulation within a Classification of Living Things unit. Employing a qualitative case study design within a natural classroom setting, the research was conducted with 26 fifth-grade students (14 girls, 12 boys) selected via convenience sampling in a public middle school in Türkiye. Over a six-week implementation period, data were collected triangulatively through participant observation, semi-structured focus group interviews, student diaries, and document analysis of student products. The data obtained were analyzed using content analysis, incorporating both deductive and inductive coding processes. Classroom observations indicated that the approach effectively integrated personal values and episodic knowledge into scientific inquiry. Furthermore, analysis of student-generated artifacts revealed deep symbolic meanings alongside accurate representations of scientific knowledge. The findings demonstrate that the Makiguchian approach substantially enhanced students' academic achievement while fostering critical thinking—specifically the ability to question classification criteria—and self-regulation through value-oriented learning processes. Overall, the results suggest that the Makiguchian teaching approach offers a theoretically grounded framework for promoting socially situated learning in science education.

Keywords: Makiguchian pedagogy; critical thinking; self-regulation; value creation; science education

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1. Introduction

1.1. Introducing the problem

The emphasis on multiculturalism and innovation in contemporary science education has intensified scholarly interest in diverse pedagogical frameworks. While the middle school science curriculum, specifically the 5th-grade unit "Classification of Living Things," typically focuses on transferring objective taxonomic information, students' attitudes toward science often decline as they advance in grade level, perceiving scientific knowledge as abstract and detached from daily life. The primary problem addressed in this study is the insufficiency of purely cognitive approaches to foster deep engagement and self-regulation. To address this, this study aims to extend constructivist approaches by integrating the value creation (Soka) pedagogy of Tsunesaburo Makiguchi (1871–1944) (Jaffe, 1993). This approach proposes that information must be examined not only cognitively (truth) but also evaluatively (meaning and benefit for the individual) (Goulah, 2013). Consequently, the instructional goal shifts from merely memorizing biological characteristics to questioning the organism's place in the ecosystem and its relationship with human life through the lens of beauty, benefit, and goodness (Makiguchi, 1989). The study posits that true self-regulation and critical thinking stem not from external academic coercion, but from the internal pursuit of happiness—defined here as the capacity to create value.

1.2. Theoretical framework: Makiguchi's value-creating pedagogy

The epistemological and ontological foundations of this research are grounded in Makiguchi's value creation pedagogy. In his seminal work, Soka Kyoikugaku Taikei (1930), Makiguchi challenged the state-centric education of his time, asserting that "the main aim of education is the lifelong happiness of the student". In this context, happiness is defined not as hedonistic pleasure, but as a dynamic process of creating value through interaction with the social and physical environment.

Central to Makiguchi's philosophy is the distinction between cognition and evaluation. Makiguchi argued that truth is a reflection of objective reality (cognition) and is not inherently a value. For example, the proposition "whales are mammals" is a scientific truth (cognition). However, value arises from the subject-object relationship (evaluation), such as the judgment that "whale conservation is necessary for the ecosystem". Makiguchi criticized modern education for confusing cognitive competence with value-creating competence, arguing that accumulating factual information does not guarantee the creation of value.

Makiguchi reconstructed the Kantian triad of "truth, goodness, and beauty" into "beauty, benefit, and goodness". Beauty represents aesthetic sensitivity and sensory satisfaction, serving as a gateway to complex values. Benefit refers to the pragmatic

utility of knowledge for sustaining and improving individual life. Goodness sits at the apex of this hierarchy, representing the transformation of individual benefit into social welfare and ecological responsibility. Thus, the Makiguchian teacher guides students from passive recipients of facts to active subjects who create value.

Although developed in the early 20th century, Makiguchi's philosophy exhibits strong theoretical alignment with the National Science Education Standards (NRC, 1996). Both frameworks define scientific literacy as the ability to use scientific concepts in daily decision-making and civic participation. Makiguchi's insistence that cognition gains meaning only through benefit and goodness parallels the NRC's principle that students should both understand and apply science. Furthermore, the NRC's focus on "Science in Personal and Social Perspectives" corresponds directly to Makiguchi's value categories of benefit and goodness. By prioritizing inquiry over rote memorization, Makiguchi advocated for inductive methods that allow students to discover truth firsthand, supporting the scientifically literate profile envisioned by modern reforms.

A review of the literature reveals a surge in theoretical interest in Makiguchian pedagogy since the early 2000s. Scholars have extensively examined Makiguchi's distinction between objective reality and subjective value (e.g., Kumagai, 2000; Miyata, 2000; Sato, 2000; Silva, 2000; Bethel, 2003; Takeuchi, 2004; Yasuda, 2008; Gebert, 2009; Goulah & Gebert, 2009; Hatano, 2013a; Inukai, 2013; Iguchi, 2014; Nagashima, 2016; Bradford, 2018; Cruz, 2020; Nagashima, 2020; Goss, 2022; Rúa et al., 2023). Other studies have explored Makiguchian perspectives in language policy, history education, and environmental ethics, defining his approach as deep anthropocentrism.

However, empirical research remains scarce. Exceptions include Park (2014), who examined value creation in mathematics, and Pagan (2001), who applied Makiguchian principles to middle school biology. This study addresses this empirical gap. It adopts an insider research approach to analyze how a seemingly objective subject like taxonomy can be transformed into a dynamic field of inquiry.

1.3. Research question and its correspondence to the research design

To address the identified problem and empirical gap, this study investigates the following primary research question: "How does teaching the topic of 'Classification of Living Things' in the 5th-grade science course according to the principles of the Makiguchian teaching approach affect students' critical thinking and self-regulation skills?" Within this framework, the study seeks answers to the following sub-problems:

How do students' inquiry-based approaches and argumentation skills (critical thinking) change when they relate scientific cognition to the values of beauty, benefit, and goodness? How do value-creation activities reflect on students' self-regulation processes (goal setting, monitoring, and evaluation)? How does the Makiguchian learning

community contribute to balancing individual interests (“small ego”) with social/ecological benefit (“big ego”)?

The research design employed in this study—a qualitative case study conducted within a natural classroom setting—was specifically selected to permit the multifaceted inferences required to examine these research problems. Unlike experimental designs that isolate variables in artificial settings, this approach allows for the “thick description” of the complex cognitive and affective transformations predicted by Makiguchian pedagogy.

To address the first sub-problem regarding inquiry and argumentation, the research utilizes a micro-genetic analysis of classroom video recordings and semi-structured interviews. This design feature allows for the real-time observation of the shift from authority-based cognition (rote memorization) to inquiry-based cognition. The interview protocols were specifically structured to detect changes in students' ability to justify classification criteria and question scientific sources. Furthermore, the analysis of student-generated artifacts, specifically the “Place in My Life” worksheets and benefit-harm diagrams, serves to operationalize the abstract concept of “Benefit.” By analyzing these artifacts, the study traces how students transform objective biological facts (cognition) into instrumental values, thereby validating the link between pragmatic valuation and higher-order critical thinking skills.

To explore the second sub-problem concerning self-regulation processes, the study employs a triangulated data collection strategy involving participant observation and reflective student journals. The research design positions the researcher as an “insider,” enabling the capture of subtle affective shifts—such as moments of “aesthetic awakening” or “happiness”—that traditional metrics might miss. The content analysis of student journals focuses on specific self-regulation markers (e.g., goal setting, error monitoring) to determine how the intrinsic motivation to create value drives autonomous learning behaviors, rather than external compliance or disciplinary measures.

The third sub-problem, which addresses the balance between individual interests and social/ecological benefits, is grounded in the physical and social restructuring of the learning environment. The transformation of the classroom into collaborative clusters serves as the primary context to observe the development of the “Big Self.” Through focus group interviews and the analysis of “Eco-scenario” problem-solving activities, the design permits the assessment of how students negotiate individual interests against collective well-being. This setting provides the necessary ecological validity to evaluate the development of social control skills and civic scientific literacy within a value-creating community.

2. Method

2.1. Research approach and design

This study adopts a qualitative research paradigm to enable an in-depth examination of phenomena within their natural contexts. The research design adopted is the case study, in which a bounded system (a specific class or group of students) is analyzed in detail within the framework of a contemporary phenomenon (the Makiguchian teaching approach) using multiple data sources. The case in this study is the 5th-grade science learning environment where Makiguchian teaching principles are applied. Adhering to the principle of inquiry in a natural setting as stated by Lincoln and Guba (1985), no external experimental manipulation was imposed on the research setting; rather, the existing teaching process was restructured with Makiguchian principles and examined within its natural flow. The study lasted six weeks, and lesson plans developed in accordance with the Makiguchian approach were implemented throughout "the unit Let's Explore and Get to Know the Living World". Video recordings of the lessons, semi-structured interviews, student diaries, and creative projects produced by the students (posters, stories, models) were used as data collection tools in the research.

2.2. Study group

This study was conducted in a natural classroom environment within the framework of the qualitative research paradigm. Adhering to the principle of examination in a natural setting as stated by Lincoln and Guba (1985), no external experimental manipulation was imposed on the research setting; instead, the existing teaching and learning process was restructured with the principles of the Makiguchian approach. The participants consisted of 26 fifth-grade students from a public middle school.

2.3. Research environment

The research was conducted in a public middle school in Türkiye, where children from middle-income families receive their education. The school's science laboratory and classroom environment were arranged to allow students to work in groups and participate actively. In accordance with the Makiguchian principle of value creation within a community, the physical arrangement of the classroom was transformed from a teacher-centered, sequential arrangement to a cluster arrangement where students could constantly interact with each other. This environment functioned as a learning environment that facilitated value creation that supported students' learning not only from the teacher but also from their peers (social constructivism). In this context, the study group consisted of 26 students (14 girls, 12 boys) studying in the 5th grade in the 2025-2026 academic year. As a sampling method, convenience sampling, one of the purposeful sampling methods, was preferred (Patton, 2015). There are three main

pedagogical and developmental reasons for selecting the participants as 5th-grade middle school students (10-11 age group). Firstly, according to Piaget's cognitive development theory, this age group is on the threshold of transitioning from the concrete operations stage to the abstract operations stage. The topic of "Classification of Living Things" requires moving from concrete observations (colour, size of the organism) to hierarchical and abstract categories (species > genus> family, etc.). The transition process from the concrete value of beauty (sensory perception) to the abstract value of goodness (social benefit) in the Makiguchian teaching approach is consistent with the cognitive development of this age group. In addition, the 10-11 age group is in the process of transitioning from an authority-based morality to a morality based on peer interaction and social norms. Makiguchi's concept of acting for the good of others is connected to the developing empathy and sense of social justice in children of this age. Students are more open to learning at this stage not only for grades but also to benefit their environment. Finally, the literature shows that interest in science tends to decrease during the transition from primary to secondary school (5th grade) (Osborne et al., 2003). The happiness-oriented pedagogical approach within the Makiguchian framework is considered to have strategic importance in maintaining and increasing student interest in the subject during this critical transition phase.

2.4. The role of the researcher

In this study, the researcher did not function as an external observer merely present for data collection; rather, they acted as an educator embedded within the classroom through prolonged engagement with the students. This positionality provided the methodological advantage of an insider's perspective, enabling the researcher to capture nuanced moments such as student hesitations, value conflicts, and critical incidents experienced by students during the classification of living things. Consequently, the study group exhibited a heterogeneous structure regarding academic achievement, offering a diverse context to examine the Makiguchian premise that every child possesses the capacity to create value commensurate with their individual potential.

2.5. Research material: Classification of living things unit

The primary teaching material for this research is "the unit Let's Explore and Get to Know the World of Living Things" in the 5th grade science teaching curriculum of the Ministry of National Education (MEB, 2018). In the standard curriculum, this unit is covered under four main headings: microscopic organisms, fungi, plants, and animals, and students are expected to be able to make basic taxonomic distinctions (e.g., vertebrate-invertebrate, flowering-non-flowering). However, within the scope of this research, the existing unit content has been redesigned and enriched according to the principles of Tsunesaburo Makiguchi's value creation (Soka) pedagogy. Traditional

textbooks and materials exhibit a structure where facts are presented in a disconnected and contextless manner, which Makiguchi (1989) criticizes as fragmented information. These materials generally focus only on the cognition (What is this?) question, while neglecting the evaluation (What is its value?) dimension. To address this deficiency, the materials used during the research were structured to align with the three core value categories of the Makiguchian understanding (beauty, benefit, goodness).

2.5.1. Visual and sensory materials (For beauty value)

Makiguchi argues that learning should begin with a visually striking stimulus. Accordingly, the following materials were utilized instead of the schematic and abstract drawings found in traditional textbooks.

Macro photo cards: High-resolution images showing the aesthetic details of living things (e.g., the eye structure of an insect or the spore sacs of a fern) were used.

Live specimens and microscopes: Students were provided with direct sensory contact with harmless live specimens (cultivated mushrooms, potted plants, pond water for microscopic organisms) brought into the classroom. These materials were used as an epistemological gateway for students to transition from the feeling of "I have to categorize" to the motivation of "I want to discover this beauty in nature" (creating beauty value).

2.5.2. Relational context cards and diaries (For benefit value)

In order to help students relate scientific knowledge to their own lives (benefit), value context materials have been developed instead of the traditional fill-in-the-blank exercises:

Place in my life worksheets: These are structured forms in which students analyse the place of each living group they learn about (e.g., yeast fungi) in their daily lives (e.g., it makes my bread rise) and its pragmatic value in human history.

Benefit-harm diagrams: These are graphical organizers that classify living things not only according to their biological characteristics but also according to their effects on the ecosystem and human health. This material is a concrete example of Makiguchi's principle that "it is not enough to know the truth, it is necessary to establish its relationship with life" (Bethel, 1994).

2.5.3. Social responsibility scenarios (For goodness value)

Problem-based learning scenarios were used as materials to reveal the value of goodness (social contribution), which is the highest cognitive and affective goal of the unit:

Eco-scenario cards: These are case analysis cards containing real-life problems such as "There is an increase in cyanobacteria in a lake in our region, how can we prevent this?" or "If the bee population decreases, what foods will we lose from our tables?"

These materials aimed to transform students from passive taxonomists into active value creators who produce solutions to protect biodiversity. In summary, the topic of "Classification of Living Things," which constituted the core instructional material of this research, was re-envisioned through the Makiguchian teaching approach in terms of both presentation style and student interaction, while the official curriculum content remained unchanged. Each instructional material functioned as a mediating tool to bridge scientific truth (cognition) and lived value (evaluation) within the student's learning experience.

2.6. Data collection tools (Observation, interview, product analysis)

This research is based on the principle of diversifying qualitative data collection techniques (Patton, 2015). It is not possible to measure the value transformation and cognitive processes created by the Makiguchian teaching approach in the student's inner world with a single tool. Therefore, the data obtained were collected in a multidimensional way through participant observation, semi-structured interviews, and analysis of student products.

2.6.1. Participant observation and field notes

The researcher spent a semester in the classroom environment of the practice school, closely interacting with students, by following prospective elementary school teachers who were doing their teaching practice in the Faculty of Education during the spring semester of the 2024-2025 academic year. Following this period, the researcher assumed the role of participant observer in the data collection process during the fall semester of the 2025-2026 academic year. As emphasized by Marshall and Rossman (1995), collecting data without disrupting the natural flow of classroom interactions is critically important, particularly with younger age groups (10–11 years). In this context, students' immediate reactions, facial expressions, and spontaneous "I found it/I saw it!" moments were recorded during the lesson. Moments in which experiences of beauty (aesthetic pleasure), as emphasized by Makiguchi, were lived (for example, reactions while examining an onion skin under a microscope) were documented with anecdotal recordings. All classroom sessions and group activities conducted throughout the six-week unit were video-recorded for later detailed analysis of student interactions and discourses. These recordings were used to transcribe verbatim the arguments students articulated during their critical thinking processes (for example, "I think this organism should belong to the fungus group; because...").

2.6.2. Semi-structured interviews

Focus group interviews were conducted to gain a deeper understanding of students' mental schemas and value judgments regarding the classification of living things. The

interviews were carried out outside regular class hours and audio-recorded to ensure that students felt comfortable and could express their views freely (Bogdan & Biklen, 2007). The interview protocol was designed to reveal Makiguchi's distinction between cognition and evaluation. Cognitive questions, such as "Why do we group living things?" and "What is the difference between vertebrates and invertebrates?", were used to assess students' current levels of subject-matter knowledge. In contrast, value-oriented questions—such as "What do you think is the value of a worm to the world?", "How can the classification knowledge students have learned be useful in daily life?", and "Why is protecting biodiversity considered a 'good deed'?"—were intended to explore students' capacities for value creation and critical thinking within the Makiguchian framework.

Additionally, to examine students' feelings and thoughts of the learning activities implemented through this approach, five open-ended questions were posed: (1) "How would you compare this lesson with your previous science lessons? What similarities and differences do you notice?" (2) "How did the implemented activities influence your thoughts about science?" (3) "What did you like or dislike in this process, and why?" (4) "Would you like these activities to be implemented in your other lessons? Why or why not?" and (5) "What do you think are the advantages and disadvantages of the activities used in this lesson?".

2.6.3. Student products and document analysis

In the Makiguchian teaching approach, learning by doing and producing tangible values are fundamental (Tabebi, 2015). In this context, the written and visual materials produced by students throughout the process were analyzed as concrete evidence of their self- regulation skills (planning, monitoring, and evaluation). Students were asked to prepare a value sheet each weekend related to the living group they learned about that week. In these sheets, students were expected not only to transfer information but also to write about a personal experience (beauty), perceived gain (benefit), or an ecological warning (goodness) related to that living group. These journals were envisioned as a primary data source for students to monitor their own learning processes. In addition, posters produced through collaborative group work illustrated how students structured, synthesized, and represented information. In the document analysis process, it was examined whether the visuals and texts used in these posters were simply copies of the information in the textbook or whether they contained a creative interpretation by the students. Lincoln and Guba (1985) stated that documents offer contextual richness in terms of reflecting the language and values of the participant. In summary, the data collection tools employed in this study aimed to capture observable behaviours through classroom observation, cognitive and affective processes through interviews, and tangible learning outcomes through product analysis. This triangulated approach enabled a rigorous examination of the multifaceted impact of the Makiguchian teaching approach.

2.7. Data analysis

The data obtained in this study were analyzed using content analysis, in accordance with the qualitative research framework. The data analysis process was carried out based on the three-stage flow model (data reduction, data presentation, inference/validation) proposed by Miles and Huberman (1994). The main purpose of the analysis is to identify the traces of the cognition and evaluation processes predicted by the Makiguchian teaching approach in the students' discourse and actions on the subject of "Classification of Living Things".

2.7.1. Data collection and organization

The analysis process began with the digitization of all raw data (classroom video recordings, audio-recorded focus group interviews, student diaries, and project documents). Approximately 18 hours of classroom interactions and interviews were transcribed verbatim. Written materials, such as student diaries and posters, were scanned, converted into text-based formats, and imported into qualitative data analysis software (MAXQDA) for systematic coding and analysis.

2.7.2. Coding process and category creation

In coding the data, a deductive approach based on the theoretical framework and an inductive approach derived from the data were used together (Patton, 2015). A draft code list was created before the analysis, referencing the value system in Makiguchi's Soka Kyoikugaku Taikei. Tables 1, 2, and 3 present a detailed overview of the coding categories, code indicators, and representative excerpts used in the qualitative analysis of student discourse, including diaries, interviews, and classroom interactions.

Table 1. Codes, indicators, and sample expressions regarding the value of beauty.

Sub-code (theme)	**Examples of student expressions (indicators)**
Aesthetic Appreciation	"The patterns on the butterfly's wings are **beautiful**, like a painting."
	"The smell of this flower made me very **happy**."
	"The veins of the leaf look so **regular/ordered**."
Sensory Awe (Wonder)	"Wow! Its image under the microscope is **incredible**."
	"I've never **seen** a living thing like this before, it's very **weird**."
	"I **can't believe** my eyes; its legs are so different."
Curiosity and Interest	"I could **stare** at this for hours."
	"Teacher, can I touch it? **I wonder how it feels**."
	"Why is its color so **bright**?"

Beauty codes refer to students' initial sensory contact with living organisms and encompass aesthetic satisfaction, emotional responses, and states of wonder. This category primarily emphasizes affective experiences rather than formal scientific

analysis. The key concepts associated with beauty codes include aesthetics, pleasure, curiosity, interest, sensory perception, admiration, and wonder. In this context, keyword analysis revealed expressions such as "beautiful, ugly, interesting, wonderful, colourful, patterned, weird, amazing, magnificent, like a work of art, and I want to look at it."

Table 2. Codes, indicators, and sample expressions regarding the value of benefit

Sub-code (theme)	**Examples of student expressions (indicators)**
Connection to Individual Life	"My mother makes tea from this plant and makes me drink it; it is **good for** my stomach ache." "I like cows because they **give us milk**." "I can **cool off** in the shade of this tree."
Safety and Protection	"We should **not eat** this mushroom; it might be poisonous." (Knowing the harm is also a benefit) "I must stay away from scorpions; they are **dangerous**."
Instrumental/Technological Value	"If there were no bacteria, we couldn't ferment yogurt; this is very **important**." "People **took examples** from bird wings when building airplanes." "The cotton plant is **necessary** for our clothes."

Benefit codes represent the pragmatic level at which students relate scientific knowledge or living organisms to their own lives, health, and human progress. This category addresses the question, "What good is this to me?" The key concepts associated with benefit codes include functionality, individual gain, health, nutrition, safety, instrumental value, and comfort. In this context, keyword analysis revealed expressions such as "useful, harmful, food, medicine, healing, dangerous, use, necessary, functionality, and making life easier."

Table 3. Codes, indicators, and sample expressions regarding the value of goodness.

Sub-code (theme)	**Examples of student expressions (indicators)**
Ecological Responsibility	"We shouldn't kill bees, or **the balance of nature will be upset**." "We must **protect** forests not just for ourselves, but for animals to live." "If we throw plastic into the sea, we are **doing evil** to the fish."
Social Benefit	"If we plant these trees, the children after us will also **breathe clean air**." "Biodiversity is the **wealth of the whole world**." "I will **tell** my friends not to pollute nature."
Empathy and Ethical Stance	"They **have the right to live** just like us." "Plucking a living thing unnecessarily is a **wrong** behavior." "Giving water to stray animals is a requirement of being a **good person**."

Goodness codes represent the highest level of value in the Makiguchian value system. They refer to a state in which students prioritize the well-being of society, the ecosystem, and future generations over individual self-interest. This level involves an ethical stance characterized by responsibility, moral judgment, and social and ecological awareness. The key concepts associated with goodness codes include social responsibility, sustainability, empathy, ecological balance, conservation, altruism, and concern for future generations. Keyword analysis revealed expressions such as "must protect, helping others, our duty, they have rights, for nature, for all of us, should not go extinct, moral concern, and respect."

A single student statement may contain multiple values and was therefore subject to cross-coding. For example, the statement "The patterns of bees are very beautiful (beauty), and they are useful to us because they make honey (benefit), so we must protect them (goodness)" was coded as value synthesis. In accordance with Makiguchi's framework, evaluative judgments such as bad, ugly, or harmful were also considered part of the evaluation process. For instance, the statement "I don't like mosquitoes at all (beauty–negative); they make us sick (benefit–negative/harm)" demonstrates a transition from the cognition level (e.g., identifying a mosquito as an insect) to the evaluation level (attributing negative value based on personal/social impact).

2.7.3. Identifying and interpreting themes

The coded data were synthesized together, patterns across the codes were examined, and main themes were established. At this stage, the transitions between students' cognitive mastery and value creation were visualized. In the interpretation process, Makiguchi's (1989) transition from cognition to evaluation theory was used as a focus of analysis. The analysis focused not only on whether students classified (cognition) but also on how they related to the organisms they classified (evaluation). For example, the visual elements in the students' products (posters) were subjected to semiotic analysis not only in terms of scientific accuracy but also in terms of the symbolic meanings (value) that the student attributed to the subject.

2.8. Validity and reliability

To ensure the credibility of the qualitative research, Lincoln and Guba's (1985) criteria were applied. To ensure data triangulation, the findings were validated with three different data sources: observation notes, student reflections, and document analysis. Inconsistencies, such as a student who appeared bored during observation writing "I was very excited" in their diary, were examined in depth. To examine the consistency of the coding process through expert review, a randomly selected 20% of the data was coded by independent researchers specializing in qualitative research and science education. The inter-coder agreement coefficient was calculated, and an inter-coder agreement exceeding 85% was achieved.

In addition to the aforementioned measures ensuring methodological rigor, strict adherence to ethical research standards was maintained throughout the study. Formal ethical approval for this research was granted by the Recep Tayyip Erdoğan University Social and Human Sciences Ethics Committee (Approval Date: [13/09/2025], Decision Number: [2025/112]). Prior to the commencement of data collection, official institutional permissions were secured from the Provincial Directorate of National Education and the school administration. Given that the study group comprised minor students, written informed consent was obtained from the parents or legal guardians of all participants, detailing the study's purpose, procedures, and the voluntary nature of participation. Furthermore, verbal assent was acquired from the students themselves. To ensure strict confidentiality and anonymity, pseudonyms were utilized in all data transcripts and reported findings. Participants and their families were explicitly informed of their right to withdraw from the study at any given time without any negative consequences, ensuring full compliance with the ethical guidelines for educational research.

3. Results

3.1. The effects of the Makiguchian teaching approach on students' critical thinking skills

Observation data indicated that students demonstrated high levels of communicative interaction in their interactions with both the teacher and their peers. Rather than relying on rote memorization of traditional classification schemes, students adopted a critical stance by posing questions such as, "Why does this organism belong to this group?" and "Is the value of an organism measured only by its usefulness to humans?" In doing so, they contextualized scientific concepts by integrating episodic knowledge derived from their personal experiences (e.g., observations of vegetation in their local environments).

Students' critical thinking skills were systematically recorded on a weekly basis using a critical thinking observation checklist. Changes observed between the pre-intervention phase and the post-intervention phase (following the six-week instructional process) were analyzed in terms of both the frequency and the quality of students' participation in classroom discussions. Table 4 presents the number of students, relative to the total class size, who frequently or consistently exhibited the identified critical thinking skills, along with their corresponding percentage distributions.

Table 4. Frequency distribution of students' critical thinking skills before and after intervention (N=26)

Indicators of critical thinking	Preliminary intervention (f)	Preliminary intervention (%)	Post intervention (f)	Post intervention (%)	Change (%)

1. Questioning scientific data/sources	4	15,4	19	73,1	+ 57,7
2. Justifying classification criteria	6	23,1	22	84,6	+ 61,5
3. Establishing a connection between knowledge (cognition) and life (values)	2	7,7	24	92,3	+ 84,6
4. Openness to different perspectives (alternative hypotheses)	5	19,2	18	69,2	+ 50,0
5. Making inferences based on cause-and-effect relationships	8	30,8	21	80,8	+ 50,0

Examination of Table 4 reveals that the Makiguchian teaching approach had a substantial positive effect on students' critical thinking skills. Prior to the intervention, only 15.4% of students showed a tendency to question the presented scientific data or textbook information; however, by the end of the intervention, this rate increased to 73.1%. This finding indicates that Makiguchi's (1989) critique of rote learning was effectively reflected in the classroom environment. Instead of viewing the teacher as an absolute authority, students developed a form of epistemological questioning, posing questions such as, "Why is this organism included in this group?" or "Can this classification be changed?".

The most notable change was observed in the skill of establishing connections between knowledge (cognition) and life (values). Initially, only 7.7% of students could relate learned taxonomic information to their daily lives, whereas this rate reached 92.3% by the end of the process. This 84.6% increase provides strong support for the study's main hypothesis. The Makiguchian teaching approach shifted students from a passive position of merely knowing the truth to an active position of discussing the value of that truth. Students critically examined a mushroom not only as a member of the Fungi kingdom but also in terms of its role as a decomposer in the ecosystem and its nutritional value.

The increase in the ability to justify classification criteria (from 23.1% to 84.6%) shows that students' ability to base their claims on evidence has improved. In the pre-test phase, explanations such as "Because it is so" or "It says so in the book" were replaced in the post-test phase by analytical statements such as "The skeletal structure and reproductive method of this organism bring it closer to the mammal group, but its habitat is different."

In conclusion, quantitative data demonstrate that the Makiguchian teaching approach transforms students' thinking processes in science lessons from superficial recall of information to in-depth analysis and evaluation.

3.2. The effects of the Makiguchian teaching approach on students' self-regulation skills

The Makiguchian teaching approach supported students to take responsibility for creating value in their own learning processes. Students' work not only presented scientific information accurately but also contained a high level of symbolic and metaphorical content. Their efforts to balance individual interests (benefit) with group success (well-being) during group work were interpreted as indicators of their self-regulation skills.

This study specifically examined whether the Makiguchian teaching approach enabled students to manage their learning processes through value-oriented motivation rather than reliance on external authority (i.e., the teacher). Table 5 presents a comparative distribution of students demonstrating high-level proficiency in the sub-dimensions of self-regulation before and after the intervention.

Table 5. Comparative analysis of students' self-regulation skills before and after intervention (N=26)

Self-regulation sub-dimensions	**Preliminary intervention (f)**	**Preliminary intervention (%)**	**Post intervention (f)**	**Post intervention (%)**	**Change (%)**
1. Setting learning objectives (Purposefulness)	3	11,5	20	76,9	+ 65,4
2. Recognizing and correcting one's own mistakes (Monitoring)	5	19,2	21	80,8	+ 61,6
3. Task orientation and time management	7	26,9	18	69,2	+ 42,3
4. Emotional satisfaction from the learning process (Happiness)	4	15,4	25	96,2	+ 80,8
5. Taking responsibility within the group (Social control)	6	23,1	23	88,5	+ 65,4

The data in Table 5 reveal that the Makiguchian teaching approach significantly improves students' self-regulation skills. This change suggests how Zimmermann's (2000) circular self-regulation model is strengthened when combined with Makiguchian values (beauty, benefit, and goodness). The most striking finding in the table is the 80.8% increase in the affective satisfaction from the learning process dimension. In the pre-intervention process, students viewed the science lesson as a mandatory task (15.4%); in the final intervention, almost the entire class (96.2%) described the process as a pleasurable experience. Makiguchi's (1989) theory that happiness is creating value is confirmed here. When students realized that the classification they made produced a

value (e.g., solving an ecological problem - goodness), they focused on the lesson without needing external discipline.

The increase in the skill of setting learning goals (from 11.5% to 76.9%) shows that students have shifted from a reactive to a proactive position. While the traditional approach was dominated by the understanding of "I will do whatever the teacher says," in the Makiguchian teaching process, students began to set personal goals such as, "This week I will classify the medicinal plants in our city and village and make a poster (benefit value)." This demonstrates the development of the intention stage, a fundamental component of self-regulation.

The increase in the dimension of taking responsibility within the group (88.5%) aligns with Vygotsky's view that self-regulation is not only an individual but also a social process, and with Makiguchi's value of goodness. Students have begun to see contributing to the learning of their group members (social value) as a prerequisite for individual success; this has indirectly improved their task orientation and time management.

The increase in students' rate of recognizing their own mistakes (80.8%) shows that the distinction between cognition and evaluation has been internalized. Students constantly revised the taxonomy diagrams they prepared not only to please the teacher, but also to accurately reflect reality and make them useful. This means that metacognitive awareness is triggered by the desire to create value.

In conclusion, statistical data shows that the Makiguchian teaching approach not only teaches science to students, but also enables them to become autonomous learners who can manage their own mental and emotional processes while acquiring this knowledge. Self-regulation has transformed from an obligation to do homework into a responsibility to create value.

3.3. Changes in students' cognition, emotions, and thoughts regarding the Makiguchian teaching approach

3.3.1. Cognitive development

This section focuses on the processes through which students perceive scientific facts and construct taxonomic knowledge, corresponding to Makiguchi's category of cognition. Table 6 presents a comparative analysis of student responses to cognitive interview questions, illustrating the qualitative shift from passive cognitive memorization to active, inquiry-based cognition following the pedagogical intervention.

Table 6. Student approaches to cognitive questions and developmental analysis

Interview questions	**Pre-intervention approach (Cognitive memorization)**	**Post-intervention approach (Inquiry-based cognition)**	**Relationship and analysis with previous findings**
1. Why do we classify living things into groups?	"Because it was written in the book," "Because the teacher wanted it," "To memorize it."	"To understand the order of the world," "To better understand the characteristics of living things and establish the right relationships with them."	The rate at which students question scientific data has increased from 15.4% to 73.1%. Classification has transformed from a mere rote memorization into a process of discovering meaningful patterns.
2. What is the difference between vertebrates and invertebrates?	"One is bony, the other is not" (Superficial definition).	"Skeletal structure determines an organism's lifestyle; vertebrates exhibit more complex movements" (cause-and-effect relationship).	The ability to justify classification criteria increased from 23.1% to 84.6%[3]. Students began to produce arguments based on biological evidence, not simply because it was so.

According to the data presented in Table 6, the most fundamental transformation at the cognitive level concerns students' understanding of the source and nature of knowledge. Within the traditional approach, cognition tends to be perceived as the passive reproduction of reality, whereby scientific information is accepted as fixed and unquestioned. In contrast, within the Makiguchian teaching approach, students begin to actively interrogate reality. While learning scientific facts—such as "Vertebrate animals have skeletal systems"—students come to recognize that such knowledge is not dogmatic but instead grounded in observation and verification. The data in Table 6 show that rather than merely memorizing taxonomic categories, students increasingly grasp the underlying logic of their construction, indicating the development of critical thinking skills.

3.3.2. Value-oriented development

This section covers the transition from cognition to evaluation process (beauty, benefit, and goodness), which is the heart of Makiguchi's pedagogy. Table 7 provides a comprehensive analysis of student responses to value-oriented interview questions, elucidating how the pedagogical intervention facilitated the internalization of Makiguchi's specific value categories of 'Benefit' and 'Goodness' in the context of biological classification.

Table 7. Value creation analysis based on students' answers to value-oriented questions

Interview questions (value areas)	**Student response / value creation indicator**	**Makiguchian value category**	**Relationship and analysis with previous findings**
3. What is the value of a worm/insect to the world?	Instead of "A disgusting animal" (Judgment), use "It aerates the soil, allowing plants to grow; it is essential for the ecosystem" (Assessment).	**Benefit and Goodness:** Recognizing the organism's role in the ecosystem (Goodness) and its agricultural benefit (Benefit).	Students have moved beyond simple judgments like beautiful/ugly and have evaluated living things in terms of their usefulness/necessity. They have questioned whether a living thing is harmful or necessary.
4. How will this information be useful in your daily life?	Instead of saying, "It will help me pass the exam" (Little Me), say, "It will help me know which mushrooms are edible and which plants are medicinal" (Vital Connection).	Benefit (Advantage): Knowledge is seen as a tool for maintaining and improving one's life.	The rate at which students connect knowledge with life has increased from 7.7% to 92.3%. Students have begun to view knowledge as a pragmatic tool.
5. Why is protecting biodiversity a 'good goodness'?	Instead of saying, "The teacher said to protect them," say, "Without bees, we won't find food; biodiversity is essential for my future and the future of society" (Responsibility).	**Goodness:** Transforming individual benefit into social welfare and maintaining an ethical stance.	Students have developed sensitivity to environmental issues and perceive the protection of biodiversity as a civic responsibility (a good goodness).

Table 7 summarizes one of the most salient findings of the study on bridging the gap between knowledge (cognition) and life (value). According to Makiguchi, a ton of factual information may not create a single gram of value. In line with Makiguchi's assertion that the accumulation of factual knowledge alone does not necessarily lead to value creation, the findings indicate that students were able to transform objective scientific knowledge (e.g., "a worm is an animal") into subjective and relational value (e.g., "It contributes to soil fertility"). Students' responses to Question 3 reflect this shift from cognition to evaluation. Furthermore, the emphasis on benefit observed in responses to Question 4 indicates that scientific knowledge was no longer perceived solely as information confined to examinations, but rather as knowledge connected to everyday life and practical human experience. In Question 5, students moved beyond individual benefit and articulated concerns aligned with the "Big Self"—that is, an expanded sense

of responsibility encompassing social and ecological well-being—thereby manifesting the value of goodness.

3.3.3. Micro-genetic analysis of a learning moment: From repulsion to responsibility

To illuminate the specific mechanisms through which the transition from Cognition to Value Creation occurs, we conducted a micro-genetic analysis of a specific classroom interaction. This vignette focuses on "Emre" (pseudonym), a student who initially exhibited strong avoidance behaviors toward the "Invertebrates" unit.

The following transcript [Table 8] captures a 5-minute interaction recorded during the laboratory session on Annelids (earthworms). The dialogue is analyzed line-by-line to trace the shift from aesthetic rejection (disgust) to ethical advocacy (goodness). Students are observing live earthworms placed on soil trays using hand lenses.

Participants: Emre (Student), Peer (Classmate), and Researcher (Teacher).

Table 8. Micro-genetic analysis of the transition from beauty to goodness

Time	Speaker	Verbal/Non-Verbal Action	Makiguchian Analysis (The Mechanism of Change)
00:00	**Emre**	*(Pulls his chair back, grimacing)* "Teacher, do I have to touch this? It's slimy and disgusting. I hate worms."	**Initial State: Aesthetic Rejection.** Emre evaluates the object solely through a negative sensory filter (Ugly/Bad). This emotional block prevents cognitive engagement.
00:45	**Teacher**	"You don't have to touch it yet. Just look through the magnifier at its skin. What do you see moving inside the rings?"	**Scaffolding for 'Beauty':** The teacher redirects attention from the holistic negative judgment ("disgusting") to specific aesthetic details, inviting sensory inquiry.
01:20	**Emre**	*(leans in hesitantly)* "Whoa... it has tiny bristles. And there is a red line pulsing. Is that... its heart?"	**Phase 1: Aesthetic Awakening.** The "red line" (blood vessel) triggers wonder. The transition from "slimy thing" to "living organism with a heart" creates an emotional bond (Beauty Value).
02:10	**Teacher**	"Yes, that is its circulatory system. Now watch. It is diving into the soil. Why do you think it moves the dirt like that?"	**Bridge to Cognition:** The teacher leverages the student's newfound interest to introduce scientific function (Cognition).
02:35	**Emre**	"It's eating the dirt? No, it's making tunnels. Wait... if it makes tunnels, air can get in, right?"	**Cognitive Construction:** Emre uses observation to construct the scientific fact: *Earthworms aerate the soil.*
03:00	**Teacher**	"Exactly. If there were no tunnels, could the roots of the tomato plants in your garden breathe?"	**Phase 2: Pragmatic Bridging (Benefit).** The teacher links the scientific fact (aeration) to the student's personal life (tomato garden). Knowledge becomes "useful".
03:15	**Emre**	*(Eyes widen)* "So, without this worm, my grandpa's tomatoes wouldn't grow well? It's actually... working for us."	**Evaluation (Value Creation):** The worm is no longer "disgusting"; it is now evaluated as "beneficial." The student re-assigns value based on function rather than appearance.
04:10	**Peer**	*(Poking the worm with a pencil)* "I'm going	**Conflict Trigger:** An external threat challenges the newly

		to squish it. It looks weird."	formed value.
04:12	**Emre**	*(Intervenes physically, blocking the pencil)* "Don't! It's not just a worm. It's helping the soil. If you kill it, you hurt the plants."	**Phase 3: Ethical Extension (Goodness).** This is the moment of transformation. Emre defends the organism not because he "likes" it, but because he understands its vital role. He moves from "Benefit" (my tomatoes) to "Goodness" (protecting life/ecosystem).

This interaction provides empirical evidence for the "Explanatory Framework" proposed in Figure 1. Emre's journey did not follow a linear path of memorizing taxonomic definitions. Instead, it followed the Makiguchian value trajectory. The microscopic view transformed disgust into wonder (Beauty/Overcoming aesthetic resistance). The connection to the tomato garden transformed scientific fact into personal benefit (Benefit/Internalizing utility). The realization of interdependence led to a spontaneous act of protection (Goodness/Ethical agency). This thick description illuminates that the increase in critical thinking scores (Table 4) is not merely a statistical artifact but the result of students actively negotiating and restructuring their value systems in real-time interactions.

3.3.4. Development in emotions and thoughts (questions 6, 7, 8, 9, and 10)

This section includes students' affective responses to the instructional process, their self-regulation skills, and their perceptions of happiness and meaning in learning. Table 9 delineates the profound affective transformation observed in students, contrasting their previous perceptions of rote learning with the aesthetic pleasure and 'happiness' derived from the value-creating pedagogical approach.

Table 9. Analysis of changes in emotions and thoughts regarding students' understanding of teaching

Theme of the interview questions	**Key student statements**	**Related self-regulation and affective dimension**	**Relationship and analysis with previous findings**
6. Comparison with previous lessons.	"We used to just listen, now we discover.", "It used to be rote learning, now it's part of our lives."	Active participation and ownership	While the traditional method remained at the level of cognition, this understanding initiated the evaluation process.
7. Perspective on science lessons	"Science course wasn't difficult at all; it's actually the art of understanding nature.", "Instead of boring terminology, we explored the world of living things.", "The lessons were very fun; I wasn't bored. I was happy.", "It didn't feel like homework; I	Happiness and aesthetic pleasure (Beauty)	The rate of emotional satisfaction (happiness) from the process reached 96.2%.

	wanted to do my own research."		
8. Liked/ Disliked Aspects	Liked: "Looking through a microscope (Beauty)", "Making posters", "Setting our own goals", "This week I planned to research medicinal plants and make a poster myself." Disliked: (Very few) "It was sometimes difficult to get along within the group."	Beauty value and social control	Visual materials (macro photographs) fostered aesthetic interest (beauty). Intragroup conflicts improved social control skills.
9. Desire to apply it in other courses.	"Yes, because learning like this helps us remember things and makes us happy.", "I would like to know what these numbers are used for in mathematics as well.", "I would like to learn what numbers are used for in mathematics in this way."	The search for permanence and meaning	In Makiguchian pedagogy, happiness is not a static pleasure, but a process of value creation. Students demand this creative process.
10. Advantages and disadvantages	*Advantage*: "We made our own plan, I realized I made a mistake in my chart and corrected it to reflect reality, we learned to protect nature (Self-monitoring)" *Disadvantage:* "We had to think more, but it was worth it (Mental effort)."	Self-monitoring and critical thinking.	The increase in self-recognition and goal-setting skills (80.8% and 76.9%) indicates a shift from external to internal discipline among students.

The data in Table 9 suggests that Makiguchi's principle, "The purpose of education is happiness," is embodied in the classroom. As students indicated in questions 6 and 7, they viewed the lesson not as an external obligation (homework/grade), but as a means of internal satisfaction. "Happiness" here should not be interpreted as hedonistic pleasure, but the joy of accomplishing something and creating value (preparing a poster, finding a solution to a problem). The statement in Question 10—"We had to think more, but it was worth it"—although seemingly negative at first glance, constitutes a salient indicator that students moved from a passive recipient role to an active evaluator position. This shift suggests that their critical thinking processes, while cognitively demanding, were effectively activated. Moreover, the observed increase in self-regulation skills indicates that students were able to cope with this cognitive challenge, a process that appears to be associated with their motivation to create value.

3.3.5. Explanatory framework: The cycle of value creation in science learning

While the quantitative and qualitative findings presented above demonstrate that the Makiguchian teaching approach enhanced critical thinking and self-regulation, it is imperative to explicate how this transformation occurred. Based on the micro-genetic analysis of classroom interactions and student discourse, this study proposes an explanatory model—The Cycle of Value Creation in Science Learning (Figure 1)—to

illuminate how Makiguchian pedagogy bridges the gap between reasoning and sensory perception.

Unlike linear cognitive models, this framework suggests that critical thinking in science emerges from a cyclical interaction between Affective Arousal (Beauty), Pragmatic Valuation (Benefit), and Ethical Reasoning (Goodness).

Figure 1 illustrates the cognitive trajectory observed in students. The process begins with Aesthetic Awakening (Beauty), which captures attention and reduces resistance to learning. This leads to Pragmatic Bridging (Benefit), where abstract facts are anchored to personal life, creating cognitive conflict (e.g., "Is this organism harmful or useful?"). Finally, this conflict is resolved through Ethical Extension (Goodness), where the student engages in high-level critical thinking to evaluate the organism's role in the broader ecosystem.

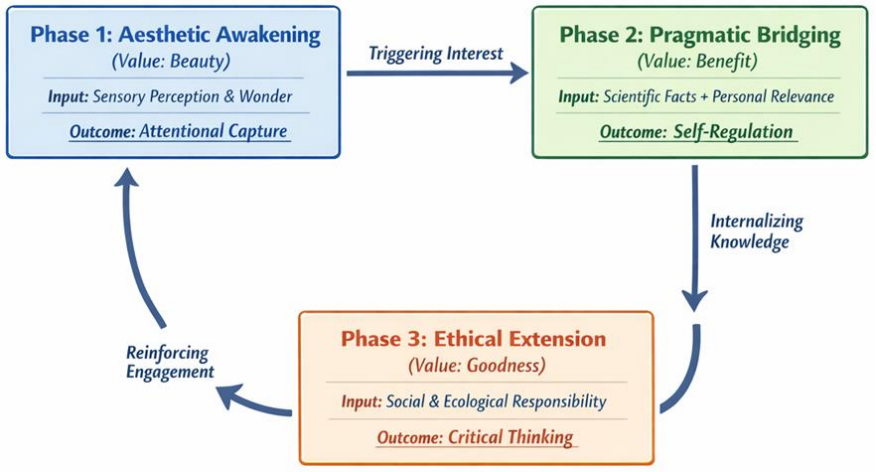

Figure 1. The cycle of value creation in science learning. The model illustrates how the Makiguchian triad of values (Beauty, Benefit, Goodness) acts as a catalyst for cognitive processes, transforming sensory engagement into critical ethical reasoning.

Unlike traditional constructivist models that primarily focus on cognitive equilibration (Piaget, 1985), the Makiguchian framework operates through a distinct tripartite mechanism that bridges the gap between objective cognition (truth) and subjective engagement (value). This mechanism functions as a continuous feedback loop consisting of three distinct yet interconnected phases: Aesthetic Awakening, Pragmatic Bridging, and Ethical Extension.

Phase 1- Aesthetic awakening (The entry point): The process begins not with a cognitive demand (e.g., "memorize this definition"), but with an affective trigger corresponding to Makiguchi's value of Beauty. As evidenced in the student logs regarding the microscopic examination of organisms, the initial sensory encounter creates a state of "positive emotional arousal." This phase functions as an attentional anchor; the aesthetic appreciation of patterns in nature (e.g., a butterfly's wing or a fern's spore) bypasses the

student's resistance to "boring" terminology. This affective priming creates the necessary cognitive opening for scientific inquiry, transforming the student's stance from passive resistance to active curiosity.

Phase 2- Pragmatic bridging (The cognitive anchor): Once attention is secured, the process moves to the intersection of Cognition (Truth) and Benefit. Traditional science education often leaves scientific facts (truth) as abstract propositions (e.g., "Fungi are decomposers"). In the Makiguchian model, this objective truth is immediately subjected to a pragmatic evaluation: "What does this mean for my life?". By linking taxonomic knowledge to individual survival and well-being (e.g., identifying edible vs. poisonous mushrooms), abstract concepts are anchored in the student's lived reality. This stage is critical for Self-Regulation; the student regulates their learning not to please the teacher, but to acquire knowledge deemed "beneficial" for their own agency.

Phase 3- Ethical extension (The critical leap): The final and most transformative phase involves the transition to Goodness. Here, the student expands their "Small Self" (individual benefit) to the "Big Self" (social/ecological welfare). The realization that one's individual well-being is inextricably linked to the ecosystem triggers high-level Critical Thinking. The student is no longer just classifying an organism; they are evaluating the ethical implications of its existence or extinction. This forces the student to engage in argumentation and dialectical reasoning (e.g., "Bees sting [harm/bad] but safeguard food security [benefit/good]"), thereby catalyzing the shift from simple memorization to complex evaluative judgment.

3.3.6. Evidence from micro-genetic analysis (video data)

To validate this theoretical model, specific "critical incidents" from the classroom video recordings were analyzed. The following vignette demonstrates how the transition from Beauty to Goodness triggers critical thinking.

Vignette 1: The "Bee Paradox" and the Emergence of Critical Evaluation Context: During the classification of invertebrates, a group of students examined a high-resolution photograph of a honeybee.

Phase 1: Beauty -> Attention (00:00 - 01:15)

Observation: Student A examines the macro photo of the bee.

Student Quote: "Look at the fuzzy hairs on its legs, they are glowing like gold! I never knew they looked so organized."

Analysis: The aesthetic appeal (Beauty) bypassed the student's fear of the insect, securing sustained attention to the morphological details.

Phase 2: Benefit -> Cognitive Dissonance (01:16 - 03:40)

Observation: Student B intervenes with a conflicting perspective based on personal experience.

Student Quote: "But it stings people! My arm swelled up last summer. It is a 'bad' animal. Why should we care about it?"

Cognitive Conflict: The group faces a dilemma: Is the organism "beautiful/complex" (Truth) or "harmful/bad" (Individual Experience)? This creates Cognitive Dissonance, forcing the students to move beyond rote classification to evaluation.

Phase 3: Goodness -> Critical Thinking (03:41 - 06:00)

Observation: Guided by the teacher's prompt ("What would happen to the flowers without them?"), Student C synthesizes the conflict.

Student Quote: "They sting to protect themselves, but they make honey and pollinate plants. If they die, we starve. So, they are 'good' for the world even if they hurt me."

Analysis: This statement represents the pinnacle of Critical Thinking. The student evaluated the organism not by a single criterion (stinging), but by weighing multiple variables (ecological role vs. immediate harm). The "Goodness" value provided the ethical framework necessary to resolve the cognitive conflict.

This micro-genetic analysis confirms that critical thinking in the Makiguchian classroom is not an isolated cognitive skill but a product of the evaluation process. The "Value of Goodness" functions as a higher-order cognitive scaffold, enabling students to construct complex, evidence-based arguments that integrate scientific facts with ethical reasoning.

4. Discussion

The findings of this study suggest that the implementation of the Makiguchian teaching approach in science education enhances students' critical thinking and facilitates learning that is socially and contextually situated. Within this framework, the topic of classifying living things was reconceptualized from a process of rote memorization into a value-oriented relationship that students establish with their environment. Students' critical thinking skills developed through the synthesis of objective scientific knowledge (cognition) and subjective value judgments (evaluation). Moreover, self-regulation appears to have been fostered through students' motivation to create value, particularly in relation to goodness as social contribution.

The findings of the study suggest that the Makiguchian teaching approach provides a significant increase in students' critical thinking skills, especially in the inquiry and association dimensions. The problem of disconnected information, which is frequently criticized in traditional science teaching (Osborne et al., 2003), was overcome in this study by using Makiguchi's cognition and evaluation distinction as a pedagogical strategy.

The data indicate that a large proportion of students (92.3%) were able to relate scientific knowledge to life through the benefit value, a result that aligns with Bethel's (1994) interpretation of Makiguchi's claim that knowledge acquires meaning only when it serves a purpose. Rather than memorizing taxonomic categories, students actively engaged in higher-order cognitive processes—such as analysis and evaluation, as conceptualized in Bloom's taxonomy—by posing questions such as, "What does this classification mean for my life?"

This finding suggests that integrating the meaning-making orientation of constructivist learning with the Makiguchian goal of value creation contributes to a shift in students' epistemological beliefs, from passive consumers of information toward active questioners of knowledge. Furthermore, the observed increase in students' tendency to question scientific information (57.7%) is consistent with Sharma's (1999) assertion that value-creating education cultivates responsible critics rather than obedient learners. The democratic classroom climate established through this approach enabled students to subject even teacher-presented knowledge to evaluative scrutiny, filtering information through a value-based lens (e.g., "Does this knowledge serve the good of society?").

The findings of the study suggest that the Makiguchian teaching approach provides a significant increase in students' critical thinking skills, especially in the inquiry and association dimensions. The problem of disconnected information, which is frequently criticized in traditional science teaching (Osborne et al., 2003), was overcome in this study by using Makiguchi's cognition and evaluation distinction as a pedagogical strategy.

While this study aligns with constructivist principles, its primary theoretical contribution lies in proposing a corrective synthesis to the limitations of standard cognitive taxonomies. The findings suggest that Makiguchian pedagogy does not merely mirror Bloom's Taxonomy but provides the missing "teleological" (purpose-oriented) dimension required for holistic science education.

Critique of the value-neutrality in Bloom's taxonomy (and its revised versions) hierarchically organizes cognitive processes from remembering to creating. However, this framework is inherently value-neutral; it describes the mechanics of thinking without addressing the ethics of thinking. Within Bloom's framework, a student can demonstrate high-level cognitive skills (e.g., "Evaluating" the toxicity of a chemical or "Creating" a destructive weapon) without any engagement with social or ecological responsibility. The data from this study (Table 5) reveals that cognitive competence (Truth) alone is insufficient to generate the intrinsic motivation needed for self-regulation.

In Bloom's model, evaluation typically refers to judging the internal consistency or validity of material (e.g., "Is this classification scientifically correct?"). In the Makiguchian model, evaluation extends to judging the relationship between the object and human/ecological life (e.g., "Does this classification help us protect biodiversity?").

As evidenced by the transition in students' discourse from "It is a worm" (Cognition/Truth) to "It is nature's plow" (Evaluation/Value), Makiguchian pedagogy transforms the static hierarchy of Bloom into a dynamic vector of "Value-Oriented Constructivism."

The proposed framework asserts that Makiguchi's triad (Beauty, Benefit, Goodness) effectively operationalizes the often-elusive "Affective Domain" alongside the Cognitive Domain. By grounding the abstract cognitive act of "Creating" (Bloom's highest level) in the ethical imperative of "Goodness" (Makiguchi's highest value), the pedagogical model ensures that student agency is directed toward social contribution. Consequently, this study posits that Makiguchian pedagogy acts as a theoretical completion to constructivism, preventing the development of "clever but indifferent" learners by embedding the cognitive capacity to learn within the ethical will to create value.

One of the most striking results of the study is that the increase in students' self-regulation skills is closely associated with the emotional satisfaction (happiness) they derived from the learning process. The intrinsic motivational force, conceptualized within the forethought phase of Zimmerman's (2000) self-regulation model, is embodied in this study as Makiguchi's pursuit of happiness. The finding that 96.2% of students perceived the process as enjoyable—while 80.8% at the same time demonstrated the capacity to independently monitor their errors—suggests that when students become cognizant of the value they create (beauty, benefit, and goodness), they regulate their learning independently of external disciplinary measures.

While homework is frequently characterized in the literature as an externally imposed obligation (Pintrich, 2000), within the Makiguchian teaching context it was reframed as an opportunity for value creation. For instance, students motivated by the value of beauty devoted sustained attention to refining microscopic observations, whereas those oriented toward goodness engaged in time management and self-control to enhance the quality of group projects. These patterns indicate that self-regulatory behaviours were not driven by compliance, but by internally meaningful goals. This finding is consistent with research in neuroeducational and affective neuroscience literature (Bielaczyc et al., 1995; Levine & Horton, 2015; Radoff et al., 2019), which suggests that the affective domain plays a facilitative role in activating cognitive control and metacognitive regulation mechanisms.

The results demonstrate that Makiguchi's value of goodness (social benefit) strengthens a collaborative learning culture in the classroom. The 65.4% increase in the rate of taking responsibility within the group illustrates that Vygotsky's social

constructivism theory is operationalized more effectively when equipped with a purpose supported by the Makiguchian teaching approach. Students demonstrated an emerging capacity to balance between the" small self" (individual grade anxiety) and the "big self" (class/group success) (Gebert & Joffee, 2007).

The topic of classifying living things has functioned as a context where students develop sensitivity to environmental problems. The fact that students dealt with the theme of biodiversity conservation in their projects shows that they perceive scientific literacy not merely as an academic competence but also as a civic responsibility. This demonstrates that the National Science Education Standards' (NRC, 1996) vision of "Science in Personal and Social Context" can be successfully implemented through the Makiguchian teaching approach.

The cognitive findings of the study (Table 6) indicate a substantial shift in how students conceptualized scientific knowledge, moving from passive acceptance toward active epistemological inquiry. While preliminary interviews revealed that students initially justified knowledge primarily through textbooks or teacher authority, post-intervention data showed a transition toward systemic understanding and cause-and-effect reasoning. This shift provides empirical support for Makiguchi's epistemological critique of authority-based cognition.

In traditional science education, students tend to perceive knowledge as fixed and absolute truths transmitted through textbooks (Noddings, 2012). In contrast, the significant increase in students' questioning of classification criteria observed in this study suggests that Makiguchi's ontological distinction between cognition (truth) and evaluation (value) functions effectively as a pedagogical strategy. Central to this transformation is the Makiguchian view that truth itself does not constitute value, but rather represents the mind's reflection of objective reality.

Whereas traditional instruction often offers a static representation of reality by asking "What is it?", the approach implemented in this study encouraged students to interrogate that reality. Students no longer positioned the teacher as an unquestionable authority but instead critically examined scientific data. As Sharma (1999) argues, value-creating education cultivates responsible critics rather than obedient individuals. This epistemological stance aligns closely with the inquiry-based learning vision articulated in the National Science Education Standards (NRC, 1996), which emphasize the development of data-driven explanations. Consequently, knowledge ceased to function as a dogma within the classroom; cognition—conceptualized, per Makiguchi, as the reflection of objective reality in the mind—became the raw material for critical thinking and epistemological engagement.

The data presented in Table 7 indicate that students perceived science not merely as an academic obligation, but as a domain of value meaningfully connected to life. The shift from describing a worm as "disgusting" (a primitive affective reaction) to defining it as

"essential for soil fertility" (a value-based ecological evaluation) reflects Makiguchi's central thesis that value does not reside in the object itself, but emerges from the dynamic relationship between the subject and the object within a learning context.

One of the most persistent challenges identified in the science education literature is students' tendency to view scientific knowledge as decontextualized and detached from everyday life. In this study, the finding that 92.3% of students were able to relate taxonomic knowledge to daily experiences (benefit value) demonstrates that this detachment can be substantially reduced through Makiguchian pedagogy. This outcome highlights the mediating role of the concept of benefit in Makiguchi's value theory. As Makiguchi (2015) asserts, even an abundance of factual information may fail to generate value unless it contributes to the improvement of an individual's life through evaluation.

Consistent with Bethel's (1994) interpretation, the Makiguchian approach facilitates a transformation from learners who merely store information to active agents who enrich their lives by meaningfully applying knowledge. Furthermore, students' articulation of biodiversity protection as a form of goodness extending beyond individual benefit reflects, as noted by Gebert and Joffee (2007), the balance established between the individual self (small self) and the social self (big self). These findings support holistic educational perspectives that conceptualize the purpose of education not only as knowledge transmission, but also as the cultivation of character, ethical awareness, and civic responsibility.

The findings in the affective and self-regulation dimensions (Table 8) indicate that happiness functions as a catalytic factor in enhancing both academic achievement and self-regulation skills. The concurrent increase in students' satisfaction with the learning process (96.2%) and self-regulatory capacity (80.8%) is notable. In contrast to traditional literature, where homework and studying are frequently treated as externally imposed obligations (fear of grades, etc.), the Makiguchian teaching approach inverts this relationship by framing learning as an opportunity for meaningful value creation (Pintrich, 2000). Makiguchi defines happiness not as a hedonistic pleasure, but as the satisfaction derived from overcoming challenges through creating value. Statements such as "We had to think more, but it was worth it" exemplify that students experience happiness as the fulfillment of value creation, rather than avoidance of difficulty.

This intrinsic motivation appears to activate the forethought and self-reflective phases described in Zimmerman's (2000) self-regulation model; it supported students' ability to set their own learning goals (76.9%) and monitor their mistakes (80.8%). Students managed their learning processes autonomously, guided by the desire to produce value (beauty, benefit, or goodness), without reliance on external discipline. Furthermore, the observed increase in responsibility within group work aligns with Vygotsky's (1978) conception of the zone of proximal development as a fertile ground for both cognitive and social value construction.

While the quantitative findings of this study demonstrate a significant enhancement in students' critical thinking and self-regulation skills, numerical data alone is insufficient to explicate the processual nature of this transformation. To illuminate how Makiguchian pedagogy bridges the gap between abstract scientific cognition and ethical reasoning, this study proposes an explanatory model based on the micro-genetic analysis of classroom discourse: The Cycle of Value Creation in Science Learning (Figure 1). Unlike linear cognitive models that prioritize content retention, this framework suggests that deep scientific inquiry emerges from a cyclical interaction between Affective Arousal (Beauty), Pragmatic Valuation (Benefit), and Ethical Reasoning (Goodness).

As evidenced in the micro-genetic analysis, students moved beyond simple classification to evaluate the ethical implications of an organism's existence. This forces engagement in dialectical reasoning—weighing conflicting variables such as immediate harm versus ecological necessity. The data suggests that the "Value of Goodness" functions as a higher-order cognitive scaffold, enabling students to construct complex, evidence-based arguments that integrate scientific facts with ethical reasoning.

5. Conclusions

This study set out to investigate the effects of Tsunesaburo Makiguchi's value-creating pedagogy on 5th-grade students' critical thinking and self-regulation within a science curriculum. The findings provide empirical support for the premise that science education can transcend the mere transmission of objective facts to become a dynamic field for value creation.

The integration of the Makiguchian triad—Beauty, Benefit, and Goodness—proved to be a potent pedagogical strategy. Quantitatively, students exhibited significant gains in their ability to question scientific sources and justify classification criteria. Qualitatively, the classroom transformed from a site of passive "cognitive memorization" to one of active "inquiry-based cognition." The theoretical contribution of this research lies in the proposed Cycle of Value Creation in Science Learning. Ultimately, this study suggests that when students perceive the learning process as a means to create value—to find beauty in nature, benefit in knowledge, and goodness in contribution—they evolve from passive consumers of information into autonomous, responsible, and happy lifelong learners.

In conclusion, the integration of cognition and evaluation enabled even a traditionally rote-learned topic, such as the classification of living things, to become a dynamic field for value creation. Students transitioned from passive information receivers to active evaluators who question reality (Sharma, 1999), apply knowledge pragmatically to daily life (Bethel, 1994), and derive affective satisfaction from the learning process. These findings provide strong empirical evidence that science education can extend beyond

understanding the natural world to fostering value creation and the pursuit of happiness within it.

6. Implications of the study

Based on the findings and conclusions of this research, the following implications are offered to researchers, program developers, and practitioners.

6.1. Implications for educators and practitioners

When introducing a topic in science instruction, the central question should not be "What will we learn?" but rather "How can we create value (beauty, benefit, and goodness) with this knowledge?" Lesson plans should be designed to integrate this triad of values. Furthermore, student achievement should be evaluated beyond conventional metrics, such as multiple-choice tests, by incorporating authentic assessment tools including value creation journals, portfolios, and social responsibility projects. Collaborative learning environments, grounded in Makiguchi's principle of human solidarity rather than traditional competition, should be established. Within this framework, peer assessment should function not as a mechanism for deficit-based error detection, but as a dialogic process to enhance students' collective capacity for value creation.

6.2. Implications for program developers

Learning outcomes in the science curricula should explicitly integrate both scientific process skills with affective and ethical values, such as sustainability and aesthetic awareness. Within teacher education programs, preservice teachers should receive comprehensive instruction that encompasses not only subject matter knowledge but also foundational pedagogical philosophies (e.g., Makiguchi, Piaget, Vygotsky, and Dewey). Such a curriculum underscores that the teacher's role must transcend that of a mere technician to become a facilitator of value creation, capable of nurturing both the cognitive and moral development of students.

6.3. Implications for researchers

This study is limited to a six-week instructional unit. Therefore, longitudinal studies are needed to investigate the impact of the Makiguchian teaching approach on students' academic achievement, character development, and other outcomes. The effectiveness of the Makiguchi value-creating model should be examined comparatively across multiple disciplines, including science, social studies, and mathematics. Moreover, ethnographic research is warranted to explore the applicability of Makiguchi's teaching approach, originally developed in Japan, in diverse cultural contexts internationally. Tsunesaburo

Makiguchi's principle, articulated nearly a century ago—"The purpose of education is the happiness of children"—remains highly relevant in the complex landscape of 21st-century education. These findings suggest that classrooms can evolve from mere repositories of information into dynamic workshops that cultivate both joy and value, providing a robust foundation for future research in this field.

6.4. Limitations

This study, while providing significant empirical evidence on the integration of Makiguchian pedagogy into science education, entails several inherent limitations that should be acknowledged and provide directions for future research. First, the research is limited by its temporal and contextual scope. Conducted over a six-week period focusing on a single unit "Classification of Living Things" with a specific group of 5th-grade students (N=26) in a Turkish public middle school, the findings may not be directly generalizable across grade levels, socio-economic backgrounds, or cultural contexts. While the qualitative case study design allowed for an in-depth analysis of the natural setting, it limits the analytical transferability of the results to broader populations.

Secondly, the role of the researcher as a participant-observer (insider research) presents both a strength and a potential limitation. Although this insider perspective facilitated a nuanced understanding of the classroom's cultural fabric and captured subtle cognitive transformations, it introduces a degree of subjectivity that could affect data interpretation despite rigorous triangulation. Furthermore, while this study focused primarily on the development of critical thinking and self-regulation through the lens of Makiguchi's value triad (beauty, benefit, and goodness), it did not extensively analyse the long-term longitudinal impact of this pedagogy on students' overall character development or academic trajectories. Future research would benefit from incorporating longitudinal designs to observe whether the value-creating habits internalized during this unit persist across different disciplines and developmental stages.

Finally, although student-student interactions were utilized to foster a value-creating community, a more detailed intersectional analysis—considering how gender, academic achievement levels, or individual cultural positionalities shape the experience of happiness and value creation within the group—would provide a more comprehensive understanding of equity in the Makiguchian classroom. Incorporating these diverse perspectives would further deepen the pedagogical insights offered here and contribute to a more inclusive model of science learning.

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