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DEVELOPING CREATIVE AND CRITICAL THINKING THROUGH STEAM PROJECTS IN EARLY ENGLISH LANGUAGE LEARNING: A CASE STUDY

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Abstract: This case study explores how project-based STEAM activities in English foster creative and critical thinking in young children. The participants were two boys, aged 3 and 5, native Serbian speakers exposed to English as a foreign language daily. A pressure-free, whole-child learning environment based on Montessori principles and Bloom's taxonomy incorporated in STEAM activities supported their authentic learning experiences within the CLIL framework. Home-based projects addressed the boys' developmental needs and interests while encouraging exploration, creativity, and critical thinking. Over three years, the researcher documented their progress through audio and video recordings, photographs, drawings, and written observations. The findings suggest that STEAM projects, combined with Montessori principles and CLIL lesson plans, enhance creative and critical thinking in problem-solving situations in English. The study highlights the benefits of conducting complex STEAM activities in early English language learning for deeper engagement in the learning and thinking processes.

Keywords: Montessori, STEAM, CLIL, early English language learning, creative and critical thinking

INTRODUCTION

The 4Cs framework—content, cognition, communication, and culture— is a prerequisite for thriving in a global society (Coyle et al., 2010). The Montessori Method and STEAM (Science, Technology, Engineering, Arts, and Mathematics) educational concepts aim to prepare individuals to tackle personal and professional challenges (Slipukhina, 2022). Introducing Bloom's Taxonomy early enhances higher-order thinking skills (Benjelloun et al., 2019). STEAM projects grounded in Montessori principles and the CLIL (Content and Language Integrated Learning) approach can foster confident and creative learners.

This study aims to investigate how the combination of these educational concepts fosters critical and creative problem-solving. The theoretical background covers valuable insights, and the methodology describes the evolution

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of two significant projects over three years of research. The findings connect theory to practice and offer solutions, recommendations, and considerations for future research.

THEORETICAL BACKGROUND

Bloom's taxonomy

Bloom's taxonomy (Bloom, 1956; Anderson, 2001) categorizes cognitive skills into six levels, emphasizing higher-order thinking, including critical and creative thinking skills.

Benjelloun et al. (2019) demonstrated this framework's impact on improving vocabulary and cognitive skills in young English learners. After 12 weeks, struggling students advanced in analysis, and high-performing students expanded their vocabulary and communicated their ideas more effectively.

Creative and critical thinking skills

Creative thinking involves synthesizing disparate ideas to form innovative solutions, with individuals drawing from personal viewpoints to address societal challenges (Birgili, 2015; National Research Council, 2011). Critical thinking complements this by encouraging the analysis of problems from multiple perspectives (Dewey, 1933; Paul & Elder, 2014). Attitudes such as risk-taking and openness enhance creative abilities (Piirto, 2011; Robinson, 2011; Sternberg & Lubart, 1991). The shift from rote memorization to critical thinking in language learning enriches communication, idea generation, and confidence in language use (Li, 2016). The CLIL approach promotes cognitive and language development through scaffolding strategies (Lockley, 2013; Wilson, 2016).

CLIL

CLIL supports language acquisition and critical thinking through engaging activities, like storytelling and playtime, contributing to vocabulary enrichment and cognitive development (Coyle et al., 2010; Prošić-Santovac & Savić, 2022). Interactive creative methods (Benjelloun et al., 2019; Widiastutu et al., 2017) enhance critical thinking, while complex topics in early English language teaching (Cameron, 2001) foster the development of language skills.

STEM-STEAM

STEM education, particularly at home, utilizes tools such as construction toys, board games, everyday materials, and online resources to foster creativity and problem-solving (Mei, 2017; Vartiainen & Aksela, 2019). The integration of the Arts in STEM—transforming it into STEAM—further nurtures higher-order thinking, problem-solving, and collaborative skills (Wai Leng, 2023; Krüger, 2021).

Montessori Method

The Montessori Method also promotes creativity through independent learning and imaginative play. This philosophy of child development encourages convergent and divergent thinking, fostering essential skills for future innovation (Robson & Franco, 2023). According to Slipukhina (2022), it aligns with STREAM education, nurturing intellectual growth and societal responsibility. It is an educational approach that enhances communication, collaboration, and effective learning at all developmental stages.

METHODOLOGY

Research design

This case study examined the developmental trajectories of two young boys, Laki (aged three) and Kiki (aged five), as they acquired critical and creative thinking skills within the context of English language learning. The research incorporated CLIL-planned lessons and Bloom's taxonomy into two STEAM projects grounded in Montessori principles as part of a three-year retrospective ethnographic study. The involvement of the mother provided and supported the whole-child approach. It captured spontaneous and prompted speech moments in English at home and in other contexts.

The primary objective of this case study is to investigate how critical and creative thinking skills emerge and evolve in early English language learning over three years of STEAM-based projects in the CLIL framework.

Participants

The research spanned the period from when Kiki was 2 years and 4 months old (2; 4) and Laki was 10 months old (0; 10) to when they reached 5 years and 4 months (5; 4) and 3 years and 4 months (3; 4), respectively. English language learning started early with nursery rhymes, which naturally extended from the classroom practices of the researcher. Serbian was the primary language for

family communication. Playtime, structured teaching sessions, and other interactions between the participants and the researcher occurred in English.

As Laki entered his second year, Kiki progressively started conversing with him in English. Code-mixing occurred but decreased.

The children's interests inspired the development of two STEAM projects: Laki's fascination with animals and dinosaurs (project "Animals") and Kiki's curiosity about nature, our planet, and the Solar System (project "The World").

Instruments

The researcher used various data collection methods, including audio and video recordings, photographs, participants' drawings, and written observational notes. Bloom's Taxonomy was applied to assess and enhance the participants' communication skills, ensuring systematic cognitive and linguistic development.

Procedure

English language learning started during playtime. As the children matured, it became evident that Montessori activities needed support for further cognitive development. The integration of STEAM-based interdisciplinary activities created additional opportunities to foster higher-order thinking. These project-based activities within the cognitive domain with CLIL lesson plans ensured the purposeful integration of content and language.

In the first year, the sessions were flexible and often included improvisation. The dynamics and complexity of projects evolved and shifted toward addressing real-life problems in meaningful contexts.

These activities promoted communication, cognitive engagement, and language development. The systematic application of Bloom's Taxonomy illustrated the progression of critical and creative thinking skills in English.

RESULTS

Table 1 presents the learning objectives for the "Animals" project. Each "C" section includes examples and explanations of critical and creative thinking in English.

Table 1. Project's objectives within 4C's framework (theme "Animals") (based on Coyle et al., 2010)

4C's Framework	Project's Objectives
Content	• to learn facts about animals and dinosaurs • to encourage respect for animals • to develop practices leading to the admiration of animals' differences • to empower critical and creative thinking

Critical thinking - analyzing (questioning, distinguishing, categorizing, and correlating the similarities between animal and human features)
The boys are working on a fossils kit. Kiki is digging and Laki is standing nearby and watching, ***Kiki 5; 1, Laki 3; 1***
K: You will see when I finish it. You have to be patient. Play something or run around. Yes, dinosaur is inside, I'll smash it out. Move Laki, I'll hit you with the hammer. (*I might hit you with the hammer*.)
Kiki found a fossil
R: Laki, what's that?
J: That's a baby dinosaur! T-Rex! I love T-Rex!
R: How do we call dinosaur bones? (*pause*) Fossils. And when we see the entire body made of bones?
J: Skeleton!
K: Do I have skeleton?
R: Yes.
K: Da li ti imaš skeleton?
R: Da, skelet. Svi imaju skelet.
K: Laki, you have skeleton!
L: Mummy, I got skeleton inside!

Critical thinking – evaluating (reflecting and commenting on the animal's appearance)
Visiting the village household and seeing some farm animals (sheep, pigs, hens) – ***Kiki 4; 1, Laki 2; 1***
L: It's a sheep!
R: It's a sheep! What does the sheep say?
L: Baaaaa.
R: Awww, look at the baby lamb, it's white and brown. It's sooo cute.
L: It's so sweet and shiny.
Laki associates the white color of the sheep's wool with the white color of the snow he experienced that same month.

Creative thinking – creating (adapting the stories to the context)
The researcher and the participants were testing the location of the light source and the changing size of shadows.
Inspired by the dark room and the flashlight, ***Laki 3; 1***
L: A scary story. (*puts the flashlight underneath his chin for a spooky effect*)
L: Once upon a time… It's a little spooooky story…a spooky…
R: A spooky…
L: Bear.
R: A bear?
L: Yes. Bear!
Laki likes children's books like "We're Going on a Bear Hunt" by Michael Rosen and "Brown Bear, Brown Bear, What Do You See?" by Bill Martin, Jr.

Cognition	• to develop participants' critical and creative thinking skills through lower and higher-order thinking questions • to develop participants' skills in asking questions that enable their critical and creative thinking skills development • to compare animals' features, footprints, food habits, sleeping habits, habitats • to compare dinosaurs, their size, features • to compare dinosaur herbivores and dinosaur carnivores

Critical thinking – analyzing (questioning and correlating the elements interacting in the experiment)
In the volcano experiment, Kiki realizes the relationship between baking soda and vinegar, ***Kiki 5; 4***
The scene for the volcano eruption was set outside, with volcano and dinosaur toys. The researcher gives Kiki vinegar to pour into the baking soda at the bottom of a volcano made from a plastic cup and aluminium foil.
R: Watch out, lava! That was the volcano eruption.
K: Can we put more vinegar? We want more eruptions. (*referring to his brother and himself*)

Critical thinking – evaluation (testing the size and shape of footprints)
Footprints in the snow (Guess whose footprint is it?)– ***Kiki, 5; 1, Laki 3; 1***
Kiki made footprints in the snow, then measured them and discovered all of his footprints. He also found Laki's and the researcher's footprints. The dogs' footprints were easy to identify, although Kiki initially pretended that they were bear footprints.

Creative thinking – creating (directing the imaginative role-play while incorporating knowledge about dinosaurs' distinctive features)
Laki wants to perform an act, starring Polar Bear (the researcher) and Triceratops (himself), ***Laki 3; 4***
L: I'm Triceratops, the herbivore. (inspired by the line in one *Sesame Street* episode about the dinosaurs)
R: But, you're a dinosaur. Dinosaurs are extinct!
L: Yes, we disappeared a looong time ago.
R: Is that a frill on your head?
L: Yes. And these are my horns, and my teeth. These are my arms.
R: How do you call your hands?
L: Manus. And these are my legs.
R: And, how do you call your feet?
L: Pes.
R: Nice to meet you my friend. I live at the North Pole. Do you like cold or warm weather?
L: Mmm…ergh…warm. Let's play "Guess Who"!
R: Ok. Me first. It likes fish, pears, and honey. And, it sleeps during winter.
L: It's a bear.
R: Yes, now it's your turn.
L: It's got a loong tail. It's got spikes. It's got small arms.
R: Is it T-Rex?
L: Yes!

Communication	• to acquire basic vocabulary, differentiate between regular and irregular nouns' pluralization rules, properly use the indefinite article "a/an" and pronouns, differentiate between Past, Present, and Future tenses, understand comparison of adjectives, and enhance the ability to describe (the language of learning) • to acquire new vocabulary and grammar through scaffolding (language for learning) • to acquire new content and language and to actively use the acquired knowledge to articulate meaning (language through learning)

Critical thinking – analyzing (explaining the difference through scaffolding)
Laki mistakes the positive and comparative forms of the adjective 'big,' and Kiki corrects him, ***Kiki 5; 4, Laki 3; 4***

K: No Laki, it's big, bigger and the biggest!

Critical thinking – evaluating (validating grammar rules in English language use)
The boys were playing outside and making lots of fish in the plastic fish mold with mud, when the researcher initiated new lyrics to the tune of the song "Five Little Monkeys", in order to provide the context for learning irregular plural nouns; ***Kiki 5; 4, Laki 3; 4***
R: Let's sing a song about fish, shall we?
Five little fish swimming in the sea,
One jumped high and hurt her fin.
Mummy called the doctor and the doctor said,
"No more fish jumping out of the sea".
The researcher removes one fish as they continue singing together until none are left. Kiki needed scaffolding a couple of times until he understood the rule. Laki required extra help, as he struggled with the irregular plural form and repeatedly said 'fishes,' although he regularly corrected himself after each instance of scaffolding.

Creative thinking – creating (adapting the imaginary scenario to the context while applying grammar properly)
Imaginary rescue scenario, ***Laki 3; 3***
Laki made a shelter using big sofa pillows to cover the gap between the sofa and the coffee table.
L: Mummy, let's hide.
R: Ugh, I'm too big.
L: It's too small. Imam ideju! I've got an idea.
R: What are we gonna do?
L: Look, volcano stopped erupting. We're safe now.
Not satisfied with his solution, he proposed another one shortly after so we could continue playing.
L: Let's make two shelters – one for you (*handing the pillow to the researcher*) and one for me.

Culture	• to develop the ability to empathize with animals • to develop an understanding of the relationships between people and animals

Critical thinking – analysis (correlating the facts and deducing a conclusion based on it)
Laki spotted a caterpillar outside, ***Laki 3; 4***
L: Look mummy, a big fat caterpillar. It's not hungry anymore. (*it's not moving because it's dead*)

Critical thinking – evaluating (validating the feelings in response to the outcome)
Reaction to the scene in the animated movie "The Land Before Time", he realized that something had happened to Littlefoot's mum, ***Laki 3; 2***
L: Mummy, I'm sad.
R: Why?
L: Dinosaur mummy.
Laki goes to sit on the floor in the corner of the room.
J: I'm so sad, mummy.
R: Why?
L: I'm so sad that dinosaur's mummy…
R: What happened to her?
J: It's not very well. It's hurt.
R: And where is she?
L: I don't know.
We hug.

Creative thinking – creating (collaboration and negotiating on the materials and colors of the bird-seed house)
Inspired by bird-watching and based on their previous knowledge about resident birds (sparrows and great tits), we decided to make a bird-seed house – ***Kiki 4; 11, Laki 2; 11***

Table 2 outlines the learning objectives for the "The World" project. Written examples illustrate the development of critical and creative thinking processes in early English language learning.

Table 2. Project's objectives within 4C's framework (theme "The World") (based on Coyle et al., 2010)

4C's Framework	Project's Objectives
Content	• to learn facts about countries and planets • to encourage respect for other nations and cultural heritage • to develop practices leading toward ecological awareness • to promote critical and creative thinking

Critical thinking – analyzing, **evaluating** (calculating, and testing the most effective transportation of water)
Playing outside in the muddy puddles, self-initiated play, ***Kiki 5; 4, Laki 3; 4***
The participants were transporting water with spades from one muddy puddle into another one with less water. Kiki found another more interesting way to transfer water. He was "making water slide" against the slightly inclined concrete plate and pouring water in the crease, whereas Laki decided to fill the bucket first and then pour the water in the other puddle.

Creative thinking – creating (building a famous bridge in London that we learned about)
We are preparing wooden blocks to build a bridge, ***Laki 3; 4***
L: Let's make a big one!
We are singing "London Bridge is Falling Down"

Cognition	• to develop participants' critical and creative thinking skills through lower and higher-order thinking questions • to develop participants' skills in asking questions that enable their critical and creative thinking skills development • to compare people, cultures, planets

Critical thinking – analyzing (deconstructing the story and correlating facts)

The fairy tale "Snow White and the Seven Dwarfs", read and told many times, raises questions in Kiki, as does the cartoon series "Numberblocks", ***Kiki 5; 2***
K: Why the king and queen live far away? Where?
R: I'm not sure. They didn't write which country, we only know that it's a country far away.
I continue telling the story.
K: Why the stepmother doesn't like Snow White?
R: Because she is jealous of her beauty.
Later on…
L: Mirror, Mirror on the wall,
Tell me,

Who's the Fairest of them all?
You are my Laki. (*we all laugh*)
The dwarfs are mentioned in the story for the first time.
K: Why is seven a lucky number? (*the number seven in the "Numberblocks" cartoon series is called "Lucky Seven"*)

Critical thinking – evaluating (predicting based on previous knowledge and arguing the given answers)

During part of a quiz, ***Kiki 5; 1***
R: Can you tell me, what is the color of the planet Mars?
K: Red.
R: Why?
K: Because it's hot and there are volcanoes. (*It is not hot, although it is red and it has volcanoes.*)
R: What about Uranus and Neptune? Are they hot planets?
K: Yes. They are hot. (*Smiling, because he likes occasionally giving the wrong answers on purpose.*)
R: Are they further from the Sun?
K: No, I see they are near.

Creative thinking – creating (solving the problem of sizes by negotiating the outcomes)

Laki was drawing family members, ***Laki3; 1***
Laki: Ovo je mama. (*Pointing at the drawing.*) Ovo je tata. (*Then draws another smaller head with features.*) Ovo je Laki. Ovo je Kiki. (*Draws a bit smaller head then the one he drew before, so he decides it is a baby.*) Hmmm… ovo je beba. (*Drawing another head for Kiki.*) Ovo je Kiki. Look, we're a family!

Communication	• to acquire basic vocabulary, differentiate between regular and irregular nouns' pluralization rules, use Past, Present, and Future tenses, learn how to ask questions, and enhance the ability to describe (language of learning) • to acquire new vocabulary and grammar through scaffolding (language for learning) • to acquire new content and language and to actively use the acquired knowledge to articulate meaning (language through learning)

Critical thinking – analyzing (questioning and structuring for a meaningful conversation)

Wishing a happy birthday to our cousin via viber video call, ***Kiki 5; 3***
R: Kiki, S. speaks English.
S: Hello, how are you?
K: I'm Kiki, I'm five. (*to excited to hear what she said*)
S: You're eating an apple?
K: Yes.
S: Is that your favorite fruit?
K: Yes. What's your favorite fruit?

Critical thinking – evaluating (experimenting on the previously made predictions)

Playing in the park, ***Kiki 5; 4, Laki 3; 4***
K: Come on Laki, don't be scared.
L: Come up, up, up! Wow, it's so fun! (after sliding down)
Kiki wants to clims backwards, in the opposite direction, going up the slide.
L: No Kiki, it's dangerous!

Kiki and Laki would communicate in English in the park with children attending school, whom are usually fascinated with their communicational skills and sometimes would ask if they had lived somewhere abroad
A twelve-year old boy B. (the boy and his dad agreed with the researcher to write down the first letter of the boy's name, but they also agreed on the boy's full name and age appearing in the research) *hears boys speaking in English while playing in the park, and addresses me*
B: Odakle su oni? Iz Amerike?
R: Ne, samo znaju da govore na engleskom.
B: Pa kako su naučili? Mali su.
The boy was then asking them to name objects in the park, translate words from Serbian to English. And every time he met them afterwards, he would great them in English and tell his friends about them.

Creative thinking – creating (collaborating while inventing a role-play)

Playing with the fire truck and the police car, ***Kiki 5; 4, Laki 3; 4***
K: I'm going to fix it.
L: I've got new ladder, I'm happy again. Weeeee! We've got new ladder. Yes, new ladder. He's fixed it. *(reffering to Kiki the mechanic)*
Changing roles, Kiki carries his traffic light in Laki's mechanic shop
K: Can you give me three new lights and one button. New.
L: The ladder is broken! (*focusing on the fire truck again*)
K: Huh… (*realizing Laki will not fix his traffic light; he switches it for the police car*) Laki, my tire is flat!
L: Yes.
K: Can you pump my tire?
L: Yes, c-c-c.

Culture	• to develop the ability to empathize with other people • to build an understanding of the relationships between people, nature, and food • to develop love for the family and the entire humanity

Critical thinking – analyzing (organizing and attributing according to size and shape)

While looking for pinecones – ***Kiki 4; 10, Laki 2; 10***
K: I found one!
L: Me too!
K: Another one!
After collecting them, we chose the ones we'd like to place on the kitchen table, arranging them to represent family members based on their shape and size

Critical thinking – evaluating (defending one's things, validating the rule of sharing, and experimenting with colors)

While painting – splashing color on a blacks sheet of paper, ***Kiki 4; 9, Laki 2; 9***
K: You don't have white. You need white.
L: I like white! (*Reaching for the watercolors.*)
K: No, those are mine!
R: Kiki, "Sharing is caring", remember?
K: Ok. (*sighs*) Here you are, Laki.
L: Thank you, Kiki!
R: Are we going to color the space?
K: Yes.
L: Like this, mummy. (*Puts the painting brush in the water and then chooses the color.*)
R: Yes, like that. So, what colors are we going to mix? When we mix yellow and…

K: Red.
R: What color do we get?
K: Orange.
R: Yellow and blue?
K: Green.
R: Blue and red?
K: Purple.

Creative thinking – creating (facilitating the existing notions of space and distance and composing them into inventive phrases)

Kiki addressed the researcher, ***Kiki 5; 4***
K: I love you to the planet Earth and back.
R: Do planete Zemlje? Ali mi živimo na planeti Zemlji.
K: Znam. To znači volim te malo. (*smiling*) I love you to the Neptune and back – znači volim te mnogo, zato što je to daleko. (*We hug and kiss.*)

DISCUSSION

The CLIL framework Coyle et al. (2010) suggested was particularly effective in promoting critical thinking in home-based learning. It allowed for the application of the English language in authentic, problem-solving contexts, consistent with Lockley (2013) and Wilson's findings (2016). The flexible nature of the lessons—especially during the first year—enabled an adaptive, responsive teaching approach that nurtured the children's natural curiosity and creativity.

Benjelloun et al. (2019) highlighted that interactive and creative teaching enhances critical thinking. This study illustrates how learning extends beyond traditional educational settings. The children's informal interactions with their mother in English played a significant role in language acquisition.

The boys' engagement with tasks such as analyzing animal fossils and features, conducting volcano experiments, constructing models, and creating imaginative stories in English exemplify the integration of Bloom's taxonomy and higher-order thinking skills' promotion—analysis, evaluation, and creation—through STEAM activities provided at home, as ones described by Mei (2017) and Vartiainen and Aksela (2019).

The analysis and synthesis of new knowledge were particularly evident in the children's ability to make connections across different areas of learning. For instance, Kiki's experiment with water transfer and the construction of a "water slide" involved critical thinking as he evaluated methods of solving a problem and came up with a creative solution. Similarly, Laki's imaginative play with dinosaur models demonstrated his ability to apply new concepts (e.g., herbivores vs. carnivores) in a role-playing context, fostering creativity and cognitive development.

The study also emphasizes the importance of scaffolding in supporting critical thinking development, particularly in language learning, as Lockley (2013) and Wilson (2016) proposed. Structured play, prompting questions, and direct language support enabled the children to refine their thinking, correct misconceptions, and engage in deeper learning, as outlined by Widiastutu et al. (2017). Cameron (2011) argued that complex concepts introduced in English language teaching can improve language skills in young learners. According to this study, these topics (e.g., dinosaurs, space, feelings) offered increased opportunities for the progression of language skills. They also encouraged thinking processes in problem-solving situations.

CONCLUSION

The findings of the "Animals" and "The World" projects underscore the critical role of thematic and content-driven activities in promoting higher-order thinking and language development. The children demonstrated significant progress in critical and creative thinking in English language learning, empowered by questioning, reflection, and imaginative play. Additionally, their ability to engage with complex topics such as animal behavior, geography, and empathy shows how early learning experiences can build a foundation for cognitive and emotional growth. These results affirm the importance of fostering inquiry-based learning in early childhood education. They also suggest that by linking content to real-world experiences, children can cultivate the cognitive and emotional tools necessary for understanding their world and engaging with others, even in a foreign language.

IMPLICATIONS AND FUTURE RESEARCH

This study has several practical implications for educators and researchers interested in early language acquisition and critical and creative thinking skills. Montessori principles, STEAM activities, and CLIL lessons offer a strategic paradigm for nurturing well-rounded learners. The findings suggest that combining these approaches can foster a deeper understanding of content while simultaneously developing critical thinking, creativity, and language skills.

Future research could explore the long-term impact of such interdisciplinary approaches on academic achievement and social-emotional development. Additionally, research could investigate how the 4Cs framework and Montessori-based methods influence problem-solving abilities in diverse cultural and educational contexts. Further studies could also examine the impact of parental

involvement in the learning process and its role in supporting cognitive and language development.

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