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Comparing Human-Designed and AI-Enhanced Science Lessons: A Pilot Study in K-5 Education

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Artificial Intelligence in Education (AIEd) is a rapidly growing field, yet concrete applications in early Science Education remain limited. This pilot study investigates the impact and perception of generative AI tools in designing and delivering science lessons in K-5 classrooms, compared to traditional human-designed instruction. The research was conducted in two phases: i) a preliminary survey involving Italian nursery and primary school teachers to assess familiarity and expectations toward educational technologies, and ii) a field intervention comparing six traditional and six AI-assisted science lessons, followed by a second structured questionnaire completed by seven teachers. Results reveal that while traditional teaching remains essential for fostering foundational skills, empathy, and real-world connections, AI/GAI tools can enhance engagement through immersive and adaptive experiences. However, effective integration requires targeted teacher training and mindful implementation. This study highlights the complementary strengths of human and AI-led instruction, advocating for balanced, inclusive, and pedagogically grounded innovation in early STEM education. However, further research is needed to evaluate long-term educational impact and scalability.

Keywords: Artificial Intelligence; Generative Artificial Intelligence; STEM; Primary Education; Science Learning; Teacher Perception**Introduction**

Artificial Intelligence in Education (AIEd) is a currently emerging interdisciplinary field that applies Artificial Intelligence (AI) technologies in Education to transform and enhance the design, process and assessment of teaching and learning [1-3]. It emphasizes the application of AI to support teachers' educational process, enhance students' learning processes and promote the transformation of the Education system [4,5]. Growing educational needs and national policy initiatives are leading to new and flourishing areas of research integrating AI and Education, adding to the existing literature on AI for education [6]. Given its potential, AI

represents a powerful asset for educational systems [3]. However, there is still a debate about the definition of AI [7] because defining the parameters of artificiality, i.e. how computers differ from human intelligence, is challenging: on the one hand, computers can only calculate, on the other hand, they can elaborate large amounts of information much faster than humans [7]. Moreover, despite its 60-year history, the educational impact and classroom applications of AI remain unclear to many educators [8-11].

Students can benefit from the use of AI through personalized learning [3]. Currently, there are many AI-based Intelligent Tutoring

Systems (ITS) available to students. These systems also adapt the educational content to the student's ability [12], making the learning experience more enjoyable for them [13]. Students can also take advantage of the use of AI (e.g. Extended Reality, XR) to undertake activities that they would not otherwise be able to do because of geographical, health (e.g. disability), economic and time constraints [13-15]. On the teachers' side, the application of AI in Science, Technology, Engineering and Mathematics (STEM) Education has the advantage of providing adaptive and personalized learning environments or resources, helping teachers understand students' behavioural learning patterns, and automatically assessing STEM learning performance [17]. However, STEM disciplines are many and diverse and selecting and applying AI techniques appropriately to the different elements of STEM (e.g. subject, information, environment) is crucial for high-quality teaching and learning [18].

As reported by [20], no previous research has examined the effectiveness of an output generated by a Generative Artificial Intelligence (GAI), such as ChatGPT (chatgpt.com), for STEM education topics or its potential applications in creating Science Education resources. There is also a paucity of published studies on its use as a research tool in Education. In fact, [21] reported that out of 63 studies analysed, only 22 reported the educational impact of AI technologies on student learning and most of them showed a significant positive impact of AI technologies on improving student learning. In contrast, only 2 out of 22 reported non-significant results [19,20]. The impact of GAI on educational and learning activities thus represents a significant and timely research gap to be addressed.

Since several reviews highlighted the lack of concrete examples of AI in teaching, in this paper we propose a concrete example of AI-generated teaching units. The aim of this paper is to compare the lessons developed by a "human" teacher with those developed using AI and GAI. To achieve this objective, we first conducted a survey on the adoption of Generative Artificial Intelligence in Education on a sample of Italian teachers from nursery to primary school. Second, 6 traditional human-generated lessons (produced using also innovative learning techniques, i.e., no frontal lessons [21] were conducted in April 2024 in 7 classes from nursery school to primary school. Third, activities developed with AI and GAI were proposed to the same teachers involved in the lessons. Teachers were finally asked to fill in an anonymous questionnaire. Specifically, lessons focused on the House Martin (*Delichon urbicum*), a small passerine bird that nests on buildings in European towns and villages, covering topics such as migration, climate change, biodiversity

and bird anatomy. The target group of the different lessons were children from nursery school to primary school (K-5 level).

The selected educational institutions where traditional lessons were carried out are in Borgaretto, a hamlet of Beinasco, a municipality in the province of Turin (Northern Italy), which houses the comprehensive institute "IC Borgaretto-Beinasco" and the nursery school "Disney". The comprehensive institute includes a middle school (Vivaldi school), two primary schools (Di Nanni and Calvino schools), and two kindergartens (Disney and Gatti schools). Specifically, the pilot project involved the fourth classes of the two primary schools (40 children), two 5-year-olds sections of the two kindergartens (45 children) and two 3-year-olds sections of the two kindergartens plus the 2-year-olds section of the nursery school (50 children).

The Survey on Human and AI-generated Teaching

To carry out the survey on the adoption of Generative Artificial Intelligence in Education, we developed an anonymous questionnaire with 12 questions, eight of which were closed (four using a 5-point Likert scale) and four open to allow the teachers to freely express positive and negative comments about both types of approaches. In the questionnaire, we proposed a hypothetical Natural Science lesson on House Martins and other Hirundines, bird migration, flight and nesting techniques according to two different methodological approaches, one traditional and one enhanced by technology: i) the "human" method involved the use of Interactive Whiteboards (IWBs), frontal or laboratory teaching, the use of storytelling, photographic paper material available to the teacher; and ii) the "artificial" method involved the use of Artificial Intelligence Tools such as web searches for information about birds, immersive flight simulation, Augmented Reality to study bird characteristics at 360°, tools for creating music, stories and drawings. We instructed the AI tool to design group-based activities for pupils aged 3 to 10.

Despite we emailed the questionnaire to teachers from different schools across Italy and shared it on social channels, we only received 27 responses (summarized in Table 1) most of them from primary schools (question 1). The vast majority (74.0%) believe that the human approach is effective (with no negative views) (question 2), while 55.6% take a middle position on the effectiveness of the artificial approach (question 3). The majority (70.4%) believe that the human approach is more motivating (question 4), while 63.0% believe that the artificial approach is more effective in attracting attention (question 5).

Table 1: The questions and answers of the survey conducted on Human and AI-generated teaching.

	Question	Answer 1	Answer 2	Answer 3	Answer 4	Answer 5
1	Where do you teach?	Kindergarten (0.0%)	Primary School (88.9%)	High School I grade (0.0%)	Other (11.1%)	
2	Based on the EFFECTIVENESS of the two approaches, give a rating to each (HUMAN APPROACH)	1 (0.0%)	2 (0.0%)	3 (25.9%)	4(25.9%)	5 (48.1%)

3	Based on the EFFECTIVENESS of the two approaches, give a rating to each (ARTIFICIAL APPROACH)	1 (7.4%)	2 (7.4%)	3 (55.6%)	4 (14.8%)	5 (14.8%)
4	Which of the following approaches do you think will promote MOTIVATION?	Human (70.4%)	Artificial (29.6%)			
5	Which of these approaches do you think Favors ATTENTION?	Human (37.0%)	Artificial (63.0%)			
6	What do you see as the STRENGTHS of the "HUMAN" approach?	Open answers				
7	What do you see as the STRENGTHS of the "ARTIFICIAL" approach?	Open answers				
8	What do you think are the CRITICS of the "ARTIFICIAL" approach?	Open answers				
9	Do you think you have the SKILLS to run an AI-based teaching unit?	1 (40.7%)	2 (14.8%)	3 (25.9%)	4 (7.4%)	5 (11.1%)
10	What do you think is most intimidating to teachers about introducing artificial intelligence into the future classroom?	Open answers				

As regards the strengths of the "human" approach in teaching (question 6), it was perceived as offering unique strengths, including the ability to foster empathy, emotional involvement and creativity. Teachers' adaptability and their capacity to build strong teacher-student relationships were highlighted as pivotal. Respondents emphasized the importance of interactive and personalized learning experiences, where students engage in hands-on activities, collaborative tasks and critical thinking exercises. Other key points included:

- i) Guidance: teachers can support students, especially in the early years of primary school, when autonomy is still developing;
- ii) Motivation and confidence: teachers help students recognize their strengths and weaknesses, boosting their self-esteem and encouraging trust in peers;
- iii) Effective communication: face-to-face interactions enhance understanding and enable the use of varied tools and strategies;
- iv) Active participation: laboratory activities, experiential learning and outdoor sessions make learning more engaging and meaningful, particularly in STEM fields;
- v) Adaptability and flexibility: teachers adjust their methods to meet the needs of students, fostering a collaborative and shared approach to education.

In summary, the "human" approach supports creativity, critical thinking, and the development of study methods, while emphasizing emotional connection and interpersonal dynamics, key for effective and sustainable learning experiences.

Regarding the strengths of the "artificial" approach in teaching (question 7), this was recognized for leveraging technology to create immersive and engaging learning experiences. Its strengths include the ability to capture students' attention through visual appeal, novelty, and immersive environments that are often unattainable in traditional settings. The use of tools like Augmented Reality allows students to "see" and "explore" concepts that would otherwise be inaccessible, fostering a deeper understanding of the subject. Other highlighted advantages included:

- i) Motivation: the approach aligns with students' everyday interactions with technology, making it engaging;
- ii) Creativity and critical thinking: activities such as creating videos or selecting music for projects stimulate students' creative and analytical skills;
- iii) Teamwork: collaborative tasks in virtual environments encourage students to work together towards common goals;
- iv) Efficiency and accessibility: the use of technology enables rapid access to information and resources, aiding research and information filtering skills;
- v) Stimulation: varied and dynamic virtual environments provide multiple stimuli, keeping students focused and interested.

In conclusion, the AI-based approach stands out for its ability to immerse and engage students through innovative technologies, offering unique opportunities to enhance motivation, teamwork, and the development of 21st century skills [22]. However, teachers raised concerns about the AI-based approach (question 8), especially its potential to limit social interaction and diminish interpersonal engagement. Respondents noted that it could lead

to isolation, diminished practical skills, and an over-reliance on technology, which might hinder critical thinking and creativity. Key challenges included:

- i) Technical barriers: a lack of necessary tools and digital skills among teachers and students was recognized as a significant obstacle;
- ii) Inclusivity issues: the approach may require a high level of autonomy and self-management, which could disadvantage younger students or those with learning difficulties;
- iii) Standardization and rigidity: there were concerns about the risk of standardized experiences that lack personalization and flexibility;
- iv) Long-term effects: the potential psychological impacts of prolonged exposure to virtual environments, especially for young learners, remain largely unknown;
- v) Dependence and misuse: overuse of artificial methods could separate learners from real-world experiences, reduce teamwork opportunities, and foster dependency on technology;
- vi) Resistance and adaptation: some educators expressed potential difficulties in integrating this approach due to resistance from colleagues or their own limited familiarity with digital tools.

In summary, while the AI-based approach offers several benefits, its lack of interpersonal connection, potential for over-standardization, and the technical and social challenges it poses require careful consideration and balanced implementation.

Slightly more than half (55.5%) of those interviewed feel they have little or no skills to deliver an AI-based lesson (question 9).

Teachers expressed several concerns about integrating AI into education (question 10), mainly about the risk of losing the human element in teaching. Such concerns included the depersonalization of education and the possibility of being replaced by AI, which could undermine their role as educators and disrupt traditional teaching methods. Key concerns identified were:

- i) Lack of training and resources: teachers highlighted insufficient tools, inadequate training programs, and the lack of continuous professional development as major obstacles;
- ii) Loss of control: the inability to fully control the information and outcomes generated by AI systems was seen as intimidating, alongside some unpredictability of AI-driven teaching methods;
- iii) Technological unfamiliarity: limited familiarity with emerging technologies, particularly among more experienced teachers, created resistance and uncertainty;
- iv) Erosion of critical thinking: teachers worried that over-reliance on AI might diminish students' and educators' ability to think critically and independently;
- v) Increased workload: adopting new methods and mastering new technologies could require significant time and

effort, potentially overburdening educators;

- vi) Fear of replacement: the automation of certain tasks raised concerns about AI gradually taking over the educator's role, reducing the value of human interaction;
- vii) Theoretical and impractical training: teachers criticized the theoretical nature of many AI training courses, which often lack practical relevance to real classroom scenarios.

In summary, teachers' concerns about AI in Education focus on its potential to disrupt traditional roles, the challenges of adapting to new technologies, and the need for better support to ensure AI integration enhances rather than diminishes the teaching experience.

Interestingly, 37.0% felt that teachers' training in new technologies was inadequate or poor, while none felt it was very excellent (question 11). Finally, 55.6% were uncertain when it comes to expressing an opinion on whether an AI-based teaching activity can improve children's STEM skills (question 12).

The Practical Example of Human and AI-generated Teaching Units

The learning objectives

The educational project focused on the House Martin, a common and easy-to-observe migratory passerine that nests in the study area (A. Senese, personal observations) and whose abundance has declined in recent years (Massa & Borg, 2018). The same topic was proposed to kindergarten children, both at the beginning (2/3-year-olds) and in the last year (5/6-year-olds), and in the fourth year of primary school (9/10-year-olds). A closely related and well-known species, the Barn Swallow (*Hirundo rustica*), with which the House Martin is often confused, was also introduced to all the children.

The learning objectives of the activities to be proposed to 2/3-year-olds were: i) to introduce these new "friends" (i.e. House martins) who may have built their nests under the school roof, ii) to address the concept of family and home also in the animal world, and iii) to do outdoor activities.

For 5/6-year-olds, the learning objectives were: i) to know new bird species (i.e. the House Martin and the Barn Swallow), ii) to discover the differences and similarities between the House Martin and the Barn Swallow, iii) to recognize some common birds and their anatomical features, iv) to learn what the nest is used for and how it is built, and v) to introduce the concepts of biodiversity and migratory routes.

Finally, the activities with 9/10-year-olds students were designed to achieve the following learning objectives: i) to understand the characteristics and behaviour of the House Martin and other birds, ii) to discover the differences and similarities between the House Martin and the Barn Swallow, iii) to recognize some common birds and their anatomical and behavioural characteristics, iv) to explore the concept of biodiversity and the impact of climate change on migratory routes, and v) to integrate interdisciplinary skills in Geography, Science, Geometry and Civic Education.

Table 2: The learning projects developed using human intelligence and AI and GAI.

	Human intelligence	AI and GAI
Nursery school plus kindergarten (2/3-year-olds)	i) Fairy tale of Paolino House Martin and his cousin Caterina Barn Swallow was told. ii) A nest was built using different materials. iii) Families of Barn Swallows and House Martins with their respective nests were painted on the classroom windows.	i) A fairy tale was created with the children using GAI. ii) The story could be modified in a collaborative way. iii) The final version, after an animated reading of the teacher to the class, was printed.
Kindergarten (5/6-year-olds)	i) Similarities and differences between the House Martin and the Barn Swallow were found ii) The children looked at the photos and listened to explanations about birds, nesting sites, biodiversity and climate. iii) An outdoor activity was proposed to understand flocks, with motor pathways to empathize with the birds.	i) Presentation of flash cards of some birds with the label “fly” “no fly”. ii) Collaborative creation of a simple rhyme. iii) With a GAI app, from the rhyme a song on birds was created. iv) A giant Merge Cube was created to visualize a House Martin and a Barn Swallow in 360° inside a 3D model, after the presentation of the differences between the two birds with IWB. v) An online jigsaw puzzle was created. vi) The children watched videos about flocking. vii) Using GAI a story and a video about climate change were created.
Primary school (9/10-year-olds)	i) The children looked at the photos and listened to explanations about birds, nesting sites, biodiversity and climate. ii) The correct picture was stuck on the exercise book, choosing between two and according to the question. iii) Pretending to be a bird, the teacher simulated flight to explain migrations.	i) Birds and the anatomy of flight were explained in a presentation made by GAI. ii) Silent bird cards were completed using Google Lens and ChatGPT to gather information. The information was summarized and inserted in the card. iii) A Merge Cube was created with 3D images of a House Martin and a Barn Swallow and their nests. iv) For migration, ChatGPT was used to know the routes and Google Earth to represent them. Children were invited to create single paths on Google Earth. v) Simulated flocks were seen by means of VR headsets. vi) After explanation of the teacher, original drawings about climate change were created by children using the generative artistic engine DALL-E.

The educational project developed by human intelligence” as sub-title

The common thread linking the different teaching moments was a sequence of images used to all the age levels (Table 2). The chosen images were all photographs except for the pictures highlighting the differences between the House Martin and the Barn Swallow.

Nursery school and Kindergarten (2/3-year-olds)

For the youngest children (2/3-year-olds), the fairy tale of a House Martin named Paolino and his cousin, a Barn Swallow named Caterina, was created. The children sat on mats on the floor and concentrated for the entire duration of the fable (about 10 minutes), which was told by the teacher standing in front of them. Like turning the pages of a book, the teacher showed the prints of the pictures (in A3 format). The fairy tale tells of the House Martin Paolino who

is often mistaken for his cousin the Barn Swallow Caterina. The two species are indeed very similar, although they differ in some features: the colour of their plumage, the shape of their tails, their calls, the type of nest they build, and the place where they nest. Giving voice to the various animals (also with onomatopoeic sounds) that live on the farms, Caterina is also greeted by the donkey, the cow, the pig and the horse, so to introduce further familiar animals to children. Particular attention has been paid to biodiversity, represented by the image of a colourful meadow, which shows the wealth of flower species and, therefore, of insects and arthropods in general. The fable ends with the arrival of Autumn, when Paolino and Caterina fly to warmer lands and greet the children (who have warmly returned the greeting). At the end of the story, the children were shown artificial nests for House Martins installed outside their school (Figure 1). The activity took approximately 30 minutes.



Figure 1: Examples of artificial nests for House Martins installed outside the schools.

The next day, to consolidate what they had learnt in the fairy tale, only the older children (3-year-olds) built an artificial nest using different materials such as wool thread, small pieces of wood and cork.

For the youngest children (2-year-olds), a family of Barn Swallows and one of House Martins with their respective nests were painted on the classroom windows a few weeks before the fairy tale and full-scale reproductions were hung in the common rooms to introduce the children to the activity.

Kindergarten (5/6-year-olds)

With the 5/6-year-olds students, the lesson started with them sitting in a semicircle. Each student was given a sheet of paper with drawings of a Barn Swallow and a House Martin (both dorsal and ventral view) and their nests. In the first activity (about 20 minutes) the children had to look at the pictures and say how many drawings there are and what they represent. Then they worked on similarities and differences, where the children had to find the details that made these birds look different or similar. Then, as in a real cinema, the children sat in rows and watched the photos projected on the Interactive Whiteboard (about 40 minutes). They started with birds they know because they are very common in the children's town (i.e. the Magpie *Pica pica*, the Hooded crow *Corvus cornix*, Carrion crow *Corvus corone*), then they moved on to birds that cannot fly (i.e. the Emperor Penguin *Aptenodytes forsteri*) and finally to animals that fly but are not birds (i.e. bats). After this first round of pictures of birds and animals that can fly, a picture of a Barn Swallow was shown, and the children were asked if they could recognize the bird. This was followed by an explanation of

why the nests of House Martins and Barn Swallows are different, emphasizing the different choice of nesting sites. The concept of biodiversity was also introduced, explaining why it is important by showing a photo of a colourful meadow (many colours mean many plant species and therefore the richness of wildlife). Seasonal climate changes have also been considered, which explains why these migratory birds cannot be seen in Italy throughout the year. All the activities were approached in an interactive way, continuing to stimulate the children's interest and attention with questions. The whole classes were always very involved, answering both questions but also taking turns to ask questions out of curiosity or to give examples from their own experience.

Finally, to understand flocks, an outdoor activity was organized in which the children experienced the V- formation flight (the typical formation of many bird flocks during long flights), using cones or markers to demarcate the play area and coloured cloths or ribbons to distinguish roles. The teacher assigned the role of leader to one child in each group (indicated by a red ribbon) and the roles of follower to the others (yellow ribbons). The leader stands in front and the other children line up behind him/her, forming a V. The leader begins to walk slowly, making sweeping movements with his/her arms to simulate wing flapping. The followers imitate the movements of the leader, maintaining the V-formation. After a few minutes, the teacher rings a bell or uses a signal to indicate a change of position: the leader moves to the back of the formation and a new follower takes his/her place. To give everyone a chance to be a leader and to rest, the change of position is repeated several times.

Teaching Sheet BIRD n.1



NAME
SCIENTIFIC NAME
PHYSICAL DESCRIPTION
FEEDING
BEHAVIOUR
NESTING
MIGRATION
REPRODUCTION
LIFECYCLE DURATION

Figure 2: An example of silent bird card created using the graphic online tool Canva.

Primary School (9/10-year-olds)

A more structured lesson was carried out with primary school children (9/10-year-olds) for 2 hours. It always started with a series of pictures of birds they knew, those that could not fly and the bat (like what was done with the 5/6-year-olds students). For each picture the children were asked to say the common name of the animal shown. Then the picture of the Barn Swallow was shown, always asking them to recognize it. At this point the lesson focused on the differences and similarities between Barn Swallows and House Martins. From time to time, children were given pairs of pictures representing i) hot and cold weather to explain when migratory birds arrive in and depart from our latitudes, ii) a Barn Swallow and a House Martin with ventral and dorsal views and their nests to highlight their differences, and iii) a farm and a town to identify different nesting habitats. For each pair of pictures, the children had to stick the correct picture in the notebook according to the question they were asked (that they also had to write on their notebook). The topic of biodiversity was also raised, with emphasis on its definition and the causes that could threaten it.

Special attention was given to the concept of migration. To explain how birds choose and can recognize migratory routes, the teacher asks the pupils (seated in the classroom with the desks arranged in two groups, leaving a corridor in the middle) how they can easily cross the classroom. Pretending to be a bird, he/she walks between the two groups of desks, following the corridor left free for passage. Similarly, birds use certain migration corridors to fly to lower latitudes and vice versa. Moreover, to understand flocks, the same outdoor activity proposed for 5/6-year-olds pupils was organized in which the children experienced the V-formation flight, using cones or markers to demarcate the play area and coloured cloths or ribbons to distinguish roles.

In the days following the lesson, the children prepared a poster with all the knowledge they had gained about the House Martin, the Barn Swallow and migratory birds in general. Finally, for the K-5 continuity project between kindergarten and primary school, a meeting was held between children of the fourth year of primary school (9/10-year-olds) and 5/6-year-olds ones, where the older children explained the contents of the poster to the younger ones. In this contest, the House Martin was the symbolic animal of the year, and all the children wore T-shirts with a House Martin.

The project developed using AI and GAI

Artificial Intelligence (AI) and Generative Artificial Intelligence (GAI) technologies were used to develop a proposal of lessons and activities for 5/6-year-olds and 9/10-year-olds students (Table 2). In addition, devices common in Italian schools (i.e. tablets, computers, interactive whiteboards) were used as technological tools.

Kindergarten (2/3-year-olds)

A fairy tale was created with the children (2/3-year-olds) using GAI. The children sat in a semicircle and were shown a PC as a machine that could do magic and create the fairy tale they were going to invent together. Thanks to the generative AI program Gammas (<https://gamma.app>), a series of slides (which in our case would be the pages of the story) was generated from a description

(prompt) written by the teacher who dictated it. The number of pages of the story is up to the teacher (up to 10 in the free version). After telling the story to the children, the teacher discussed with them how the story could be modified. In a fraction of a second, always thanks to GAI, a new story was generated with the children's new suggestions. Indeed, Gammas allows editing slides after they have been created and displayed. The application also allows choosing the backgrounds and thus the style of the presentation or editing and saving the images. In addition, the application allows exporting the presentation in pdf or png format, so that the story could be printed and displayed in the classroom or copied and included in each child's workbook.

Kindergarten (5/6-year-olds)

The teacher illustrated on the Interactive Whiteboard/Smartboard different bird species and their names to introduce birds to the children. At the same time, he/she wrote the list of birds on a sheet of paper on the whiteboard with the words "flies" or "does not fly" next to them. He/she also presented pictures of bats as animals that can fly but are not birds. Through brainstorming, a little nursery rhyme was created, which, thanks to GAI, became a ditty to help remember the names and characteristics of the birds. With a GAI app (text to music such as <https://ilovesong.ai/>), by writing the text of the invented nursery rhyme and giving the appropriate variables such as "happy music for children" and choosing the voice, the song was created, downloadable in mp3 or mp4 formats (useful because it generates also the poster of the song). The children will then learn to sing it, helped by the lyrics if they can read.

The second part focused on the differences between a House Martin and a Barn Swallow by also playing the different calls and showing the Interactive Whiteboard/Smartboard images, such as those available online at <https://birdaware.org/solent/swift-swallow-martin/>. A giant Merge Cube (i.e. a holographic cube for Augmented Reality) was then created for the different groups of children to visualize a House Martin and a Barn Swallow in 360° within a 3D model. Then, the children are asked to fill in a paper form with the differences between the two species. Finally, an online jigsaw puzzle was created with images of the two birds that can be done online on tablets. This can be easily created using online resources like <https://puzzel.org/it/jigsaw>, where the number of pieces can be set. Once created, the teacher uses a QR code displayed on the Interactive Whiteboard/Smartboard to give the children access to the puzzle.

The third part is about flocking. After explaining the reason for flying in a V-formation, the teacher shows a picture and a video (accessible via QRCode) on the Interactive Whiteboard/Smartboard showing beautiful choreographies.

Finally, the topic of climate change and how it can affect migratory birds is discussed. Together with the children, a story about climate change was created with a Barn Swallow and a House Martin as the main characters. This is done by brainstorming story ideas by asking the children: i) where do the Barn Swallow and the House Martin live? ii) what adventures might they have together, and iii) how does climate change affect their journey? Then, using ChatGPT, a draft of the story was created, using a prompt such as

"Create a story about a Barn Swallow and a House Martin facing climate change on their migration journey". Finally, a GAI tool can be used to create a video of the story (e.g. Animoto <https://animoto.com/> or Animaker <https://app.animaker.com/>).

Primary school (9/10-year-olds students)

The first activity introduced children to birds and the anatomy of flight, and an Interactive Whiteboard, tablets/computers with Internet connection for each group of children and a Cloud sharing environment were needed. The slides were prepared using GAI to speed up the process. An example of a program that automatically generates slides from a prompt is <https://smallppt.com/>. Next, the children are divided into groups of up to 4 children and receive silent bird cards (2-3 cards per group) with only the bird picture. In this case, the graphic online tool Canva (www.canva.com) was used to easily create the cards (see example in Figure 2). To each group, a card with a House Martin and one with a Barn Swallow were provided to highlight the differences between these birds. To complete the silent cards, the children in each group scanned the picture of the bird on the card with the tablet and submitted the pictures to Google Lens. The application returns several pictures of the bird with the exact name to be entered on the card (they were amused to see so many pictures of the same bird with the same name underneath). Then, using ChatGPT, each group creates prompts to complete the card with the information to be entered, such as scientific name, physical description, feeding and nesting behaviour, migration, reproduction and life-cycle length. At this stage, it is very important to explain to the children that any information found will have to be verified. In case of digital learning, the teacher can plan to do some collective correction work on the Interactive Whiteboard at a later stage by doing a search on a browser (e.g. by typing *Hirundo rustica* in Google). A summary work was also required to summarize the information found and place it didactically on the card. At the end, the cards were photographed with the tablet and shared in the prepared Cloud.

Augmented Reality (AR) can be used to study the specific characteristics of the House Martin compared to the Barn Swallow, for example the Merge EDU suite that makes it possible to have a 360-degree view of objects and to place them in the surrounding space, bringing them to life. With the students, proceed as follows: i) introduce the concept of Augmented Reality by first building the Merge Cube, ii) visualize it with existing resources (e.g. the globe), iii) create 3D images of the House Martin and the Barn Swallow and of their nests to examine them in 360° by searching for the resource on the web or scan the real animal in 3D with a smartphone.

The second activity was about migration routes and the flock behaviour. First, the teacher introduces the topic of migration by creating an "intelligent" multimedia presentation, using an online resource aggregator (e.g. Nearpod.com), i.e. an application capable of creating slides, containing an extensive library of ready-to-use resources and the ability to "automatically" insert YouTube links or other material owned by the teacher. To understand migration routes, the teacher uses ChatGPT on the Interactive Whiteboard by simply asking the question: "What are the migration routes

of House Martins and Barn Swallows?" ChatGPT returns a list of the main migratory routes of the two species by continent and geographical area. Next, the teacher demonstrates on the IWB how Google Earth works by: i) creating a new project, ii) assigning a placeholder for the starting point, a middle point and an end point, connecting them with lines, iii) enriching the placeholder with photos or descriptions.

Children connect to the shared project and independently plot the routes given by Google Earth directions. Finally, the project is viewed and discussed on the IWB, where all the routes are displayed.

To understand flocks, the teacher introduces the topic through a multimedia presentation with links to pre-selected YouTube videos or simulations. The children then experience flying and being in a flock through immersive technology, using a 3D model and special VR headsets connected to the tablet. It is easy to use models on platforms such as Sketchfab (link to example video sketchfab.com - 3d model of animated flock-birds), which offers simulation videos that are interactive, immersive and, above all, allow users to see the flock from all angles.

Finally, the third activity focused on biodiversity and the effects of climate change. The teacher introduced the pupils to climate change and its causes (e.g. greenhouse gas emissions, deforestation) using a prepared multimedia presentation. He/she explained how climate change affects the environment, wildlife and human communities, especially migratory birds. He/she introduced the idea that art can help communicate climate change issues and explained how a Generative Artificial Intelligence tool for creating images (e.g. DALL-E integrated in ChatGPT) works. The children then work in groups using tablets and ChatGPT to create an original piece of art about climate change (e.g. a flooded city of the future) using the integrated DALL-E model. Finally, they discuss together how art can be used to communicate important environmental messages by sharing the images uploaded to the cloud.

In view of future perspectives for understanding migratory routes and the flight of flocks, we could include the development of flight simulations and the creation of immersive XR experiences, where the student is taken (virtually) with the birds of the flock and sees what happens inside the flock during the flight. In this case, however, the school needs to be equipped with state-of-the-art devices to handle immersive and 3D imagery, but few schools have the resources to purchase them. Nevertheless, now VR apps on the subject are lacking.

Human vs. Artificial Intelligence: A Discussion in the Light of the Concrete Experiment

The concrete experiment compared two teaching approaches (i.e. one traditional, entrusted to the "human" teacher; and one based on AI and GAI) in the teaching of Science concepts to 3-10-year-olds (K-5). At the end of the experiment, the teachers involved were asked to fill in an anonymous questionnaire with 10 questions, eight of which were closed (using a 5-point Likert scale) and two open to allow the teachers to freely express positive and

negative comments about both types of lessons (i.e. human- and AI-generated). Given the limited number of teachers/educators involved (7), we discussed their responses by comparing them with the available literature.

From the analysis of the concrete activities carried out and the feedback from the teachers involved, strengths and critical issues emerge which, if placed in an appropriate theoretical framework, can provide insights for both researchers and teachers.

“Human” approach: Enhance direct experience and real-world context

Traditional teaching but delivered using active methods (i.e. avoiding the purely frontal lesson), encouraged direct observation and knowledge building from workshop activities, outdoor experiences and peer interaction. As teachers (involved in the concrete experiment) pointed out, the opportunity to show the children artificial nests and to set up group activities (e.g. the ‘V-formation flight game’) facilitated the development of exploratory, motor, communication and interpersonal skills. In fact, they highlighted that one of the main advantages of the “human” approach lies in its ability to stimulate direct observation and a real connection with the surrounding environment. Teachers highlighted that this method fosters exploration of the physical world through sensory engagement and hands-on observation. These activities facilitate the development of critical and exploratory skills, essential for a deep understanding of scientific concepts, especially in the early stages of education. The relationship with the real context not only stimulates curiosity but also fosters more intuitive and multisensory learning.

These observations are supported in the literature where experiential learning and outdoor play are seen as central to the development of young children’s science skills [23-25]. Many authors also believe that early and frequent exposure to nature, before the introduction of advanced technology, can enhance curiosity and intrinsic motivation towards STEM disciplines [25,27]. For example, [24] promotes nature-based learning experiences and often warns against the premature introduction of technology, emphasizing the importance of direct contact with the natural world and suggests that linking the curriculum with a real-world commitment not only equips students with the thinking skills needed for any test presented to them, but also helps them grow as responsible citizens and stewards of the Earth. Moreover, [26] highlighted how children learn best through direct, concrete and multisensory experiences, believing that technology can interfere with these processes.

In this context, the Italian National Guidelines for the Curriculum of 2012 (updated in 2018 [27]), at the basis of the educational programming of kindergarten, establishes for the fields of experience (thematic areas fundamental for the learning and development of children aged 3 to 6) educational environments that encourage autonomy, discovery and a sense of belonging, keeping play and exploration at the centre of learning, favouring outdoor environments where possible.

“Artificial Intelligence” approach: Potential for personalization and immersion

Lessons incorporating AI tools allowed creating dynamic and personalized contents: fairy tales generated with “text-to-slide” applications (Gammas), songs with “text-to-music” (iLoveSong), online puzzles, “silent” worksheets completed in real time by the children via ChatGPT and Google Lens. In fact, the teachers involved in this pilot study stated that it offers innovative learning opportunities that expand the scope of educational possibilities: AI enables children to personalize and manipulate images, fostering creativity that is often harder to achieve through traditional methods. These observations agree for example with [28,29], who reported that these activities stimulated curiosity and active participation, particularly through elements of novelty, immediacy and digital manipulation (Augmented Reality and VR). In fact, GAI tools can make learning more engaging by introducing emerging technologies, such as Augmented Reality and AI systems, which allow children to visualize and interact with abstract concepts in new ways. For example, [29], among the key benefits of using AI in science, highlighted adaptive and motivating content and teaching methods for increased engagement, as well as personalized tutoring through progress monitoring and feedback, and facilitating collaborative and inclusive learning.

Additionally, the teachers involved thought that the AI method promotes the development of technological and collaboration skills, as many activities require children to work together, share ideas, and solve problems creatively. Several studies highlight how immersive technologies and artificial intelligence applications can promote more inclusive and motivating learning, especially when used to provide appropriate cognitive challenges, real-time feedback and opportunities to co-construct content [3,4,17].

On the other hand, [28] underlined the need to educate young people about AI, considering its now pervasive presence in children’s daily lives, even unconsciously. AI-based tools, such as video games and virtual assistants, are part of children’s daily lives, and they interact with these technologies on a regular basis. Such interactions often lead children to develop an overestimated perception of AI’s capabilities, attributing superior abilities to it. For this reason, it is important to introduce the fundamental concepts of AI, its applications and its limitations from a young age. Although the literature review highlights a dearth of studies on the use of these technologies with young children, recently, the number of studies on AI education in early childhood has increased significantly [30-33], bringing out their positive potential to facilitate learning, making these technologies effective in concretizing abstract concepts and in fostering educational mediation.

For instance, [23] argue that, in early childhood, children do not yet possess the metacognitive sophistication necessary to fully benefit from learning resources devoid of interactivity. In this sense, interactive educational technologies, such as Augmented Reality (AR) Apps and Artificial Intelligence (AI) tools, can offer significant support, as they allow children to actively interact with educational materials. Given that formal scientific theories and models are not

developmentally appropriate for this age group, the most effective approach is to engage children in practical experiences of observing and representing natural phenomena, activities that promote basic scientific skills such as observation, description and explanation.

This type of experience not only helps to build rich conceptualizations, which prepare children to understand more complex scientific ideas in the future, but can also be considered an extension of play, stimulating curiosity and experimentation, preferably in natural environments [23].

Artificial Intelligence Education is closely linked to STEM Education, as both require creative exploration that can motivate children to create something personally meaningful and relevant. For example, [34] associate AI with STEM education to promote Project-Based Learning, passion, play, and peer interaction, using AI-centred educational activity. In line with this, [33] argue that younger children, being concrete thinkers and active learners, particularly benefit from practical approaches in STEM learning. Some authors (e.g. [34]) have considered developing an AI- specific curriculum for early childhood Education, while other studies (e.g. [28,30]) have examined the impact of AI-based toys or robots in interaction with preschoolers, highlighting how these tools can improve children's creativity, emotions, collaboration and literacy skills.

The introduction of AI in Education also offers the possibility of more personalized, flexible and inclusive learning. [35] summarizes some of the most widely applied educational artificial intelligence (AIED) technologies and their benefits, including the ability to facilitate different forms of interaction, increase student engagement, generate adaptive learning materials, provide meta-cognitive suggestions, create enriched learning environments, and improve overall learning outcomes.

Children's attention, motivation and management of learning rhythms

A critical issue shared by teachers involved in this pilot study is the difficulty in keeping children's attention. This is especially critical in early education, where attention and engagement are essential for effective learning. While the AI approach, according to teachers, quickly captures their interest because of its "captivating" features (e.g. visual effects, animations, augmented reality), it can lead to fragmented learning sessions or to learning sessions that are overly dependent on the playful digital element. On the other hand, "human" teaching seems to favor longer periods of concentration when working on direct or laboratory experiences, even though they may be less "spectacular" in the short term. These observations are in agreement with other studies conducted on attention and interest in learning and reporting that technology can be a powerful tool for engaging students, but only if used consciously and designed with clear psychological principles [23,25,35,36].

The available literature suggests alternating moments of low-tech active teaching with moments of more immersive experimentation to avoid cognitive overload and maintain intrinsic motivation to learn [35,37,38]. Principles such as cognitive load

theory [35] and self-determination theory [38] suggest that the use of AI in the classroom needs to be calibrated, respecting children's processing capacity and fostering autonomy, competence and social relationships. Therefore, understanding how and when to use technologies, avoiding cognitive overload and promoting intrinsic motivation, is crucial to maintaining high levels of attention and interest in learning. [4,38,39] analysed how Augmented Reality can improve learning, motivation, and memorization of Science in primary school students using research and development methodologies. In a study on the use of multimedia in school, [40] found that the integration of words and images, when designed according to certain principles (such as the principle of segmentation and the principle of spatial and temporal contiguity) can support attention and interest, making learning more engaging and reducing cognitive load.

On the other hand, [35] attributed to cognitive load the attention and involvement of students in the classroom, since working memory has limited capacity and even technologies, if not properly structured, can overload it. [38] attributed the fundamental role for educational success to intrinsic motivation in learning (self-determination theory), giving technologies a positive role only if designed to meet the three fundamental needs of autonomy, skills and relationality. Moreover, [37] posited the variable of the involvement of children themselves in the design of activities with educational technologies for their actual success in terms of improving attention and interest. Finally, the maintenance of attention and interest seems to depend on the ability of the content to challenge and stimulate students cognitively, regardless of the presence or absence of technology [41].

Therefore, the use of AI requires a balanced educational approach that alternates moments of technological stimulation with moments of reflection and direct interaction, to prevent learning from becoming too superficial or fragmented.

The role of the teacher and the need for training

The introduction of AI tools into the classroom raises the issue of teacher training and support. In the questionnaire, many teachers expressed the need for guidelines and training opportunities to acquire not only technical skills but also appropriate pedagogical strategies to integrate AI effectively (in agreement with [42-44]). In fact, as reported by [44-47] there is a lack of systematic research and detailed guidelines to develop resources and training programs for teachers. Several studies [48-51] emphasize that the mere presence of technology does not guarantee effective use, but a didactic "mediation" is needed to guide learning and promote the acquisition of critical skills. The lack of structured training on how to integrate AI into teaching significantly limits the effectiveness of the AI method and there is a risk that teachers' feelings of inadequacy will be perpetuated, limiting their adoption or leading to superficial use of the tools [52-55]. Clear explanations about how AI works can reduce concerns and increase teacher confidence [52-55]. This training gap highlights the need for targeted educational policies that invest in teachers' technological preparation, as well as a gradual and thoughtful introduction of new methodologies.

Moreover, this requires future research focused on creating comprehensive frameworks and specific training practices to support educators in adopting AI and GAI [42,57,58]. Studies such as [43,58-62], focusing on teacher training and the integration of AI into the school curriculum, stated that future research should use theories such as self-efficacy and self-determination to analyse teacher motivation and preparation, explore misconceptions about AI and improve teachers' digital skills for effective implementation of educational technologies.

As also suggested by [49], teachers need continuous professional development paths that include practical examples, pedagogical use cases and methodologies to evaluate the effectiveness of AI and GAI resources.

Perspectives and equity of access

Another aspect that emerged from the survey is the economic and infrastructural difficulties many schools face in acquiring software, hardware (e.g. VR viewers, tablets, upgraded PCs) and support resources. For example, ChatGPT 4 (developed by OpenAI), with its optimal functions, is available on a paid subscription basis, so free solutions should be tested to see if they work properly, but they usually have a limited number of prompts and then become paid for. As a result, many school managers, evaluating how to spend available funds, may or may not choose to focus on innovative didactics based on the latest technologies. This can create territorial and social inequalities and slow down the adoption of innovative solutions. The risk is that without adequate investment and support policies, teaching with AI will remain an elitist option.

There is also the issue of language, as much AI software and interfaces are only available in English (e.g. <https://dashboard.mergeedu.com/>, <https://sketchfab.com/>), which makes younger children and non-English-speaking teachers uncomfortable (e.g. this situation occurred during this experiment). The need for translations or user-friendly versions in local languages is highlighted also in studies investigating the digital divide and the usability of e-learning platforms [48,63].

Moreover, AI systems can perpetuate biases that are present in the data on which they are trained. This may result in unequal outcomes, especially when biases involve race, gender, or socio-economic background [63]. For example, in its "Educator Considerations for ChatGPT" documentation, OpenAI states that there are several education-related risks to using ChatGPT, including plagiarism, harmful and biased content, equity and access, the trustworthiness of the AI-generated content, and overreliance on the tool for assessment purposes [64].

Conclusion

The use of AI in education is a cutting-edge topic, and this study fills a gap in the literature by providing concrete examples of the application of AI and GAI in Science Education (K-5). In this study we propose a direct comparison between traditional teaching (entrusted to the "human" teacher) and teaching developed thanks to AI and GAI tools. This perspective allows highlighting both the

pedagogical aspects related to frontal and laboratory teaching and the possible advantages of AI in the creation of multimedia, personalized and immersive content. In this paper we combine an exploratory survey (questionnaire aimed at teachers) with a pilot study in the field, which is useful for understanding teachers' perceptions, training needs and initial practical reactions to the use of AI in the classroom. The survey investigated teachers' perceptions of adopting AI and GAI in Education, based on 27 responses primarily from primary schools. Moreover, in this pilot study, we tested the integration of AI and GAI in K-5 Science Education in lessons focused on the House Martin, covering topics such as migration, climate change, biodiversity and bird anatomy. The target group of the different lessons were children from kindergarten to primary school (K-5 level). These practical teaching activities are based on a concrete theme close to the children's experience (House Martin observation and the theme of migration), making it easier to transfer the results to other disciplinary contexts. Our pilot study demonstrates promising potential but also reveals challenges that need to be addressed for effective and inclusive implementation.

The comparison between the two approaches (i.e. the traditional "human" and the "Artificial Intelligence" one) shows that both have distinct and complementary strengths. While traditional teaching continues to play a crucial role in developing foundational skills, encouraging personal interaction, and connecting students with the real world, the integration of AI offers interesting prospects for broadening and enriching the educational experience through adaptive, engaging, and immersive tools.

However, to fully harness AI's potential, it will be essential to invest in adequate teacher training and implement a thoughtful and balanced use of these technologies, considering the cognitive needs and attention spans of students. Teachers need to be helped to acquire both the technical skills and pedagogical strategies to integrate AI effectively. Addressing this technology literacy gap will enable teachers to facilitate meaningful AI-based learning experiences, thereby reducing inequalities in access to and understanding of technology. Barriers also remain, particularly regarding the economic and technical resources required for advanced AI applications such as Virtual Reality (VR) and Extended Reality (XR). Currently, many educational institutions lack the infrastructure and budget to support immersive technologies, and the limited availability of science-specific VR applications exacerbates this challenge. Future investments in Education policy could reduce these inequalities by ensuring that all schools have equal access to innovative resources.

In terms of future directions, AI could play a transformative role in adapting educational content to different age groups and cognitive levels, offering new ways to explore complex scientific phenomena that may be difficult to convey using traditional methods. The development and implementation of adaptive AI tools that specifically adapt to the evolving needs of K-5 students would open new avenues for personalized, engaging and impactful education.

Finally, the ethical and social considerations of integrating AI into Education should not be overlooked. It is crucial to adopt responsible practices that protect the privacy of student data and prevent over-reliance on technology that could impact critical thinking and social skills. A balanced approach that combines the strengths of AI with the irreplaceable value of human experience is the way forward. In this context, AI should be seen not as a replacement but as an enhancement to human learning, providing tools that, if used thoughtfully, can foster an inclusive and holistic learning environment.

The desired outcome, as emphasized by the teachers involved in this study, is an educational model that does not pit the “human” element against technology, but knows how to combine the best practices of both, enhancing the value of direct experience, the teacher-learner relationship and the personalization offered by AI and GAI systems [65-69].

Acknowledgements

The authors are grateful to the teachers and educators involved in the concrete experiment in the schools of Borgaretto and to all the anonymous teachers and educators involved in the survey.

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