International Journal of Social Robotics
https://doi.org/10.1007/s12369-025-01321-7

Smart Nudging in Education: The Impact of Voice-Based Robots on Value Co-Creation

Cristina Mele[1] · **Tiziana Russo-Spena**[1] · **Irene Di Bernardo**[1] · **Angelo Ranieri**[1]

Received: 14 November 2024 / Revised: 6 September 2025 / Accepted: 10 September 2025

Abstract
This study investigates the role of voice-based educational robots in fostering value co-creation focusing on how their personalised and adaptive interactions affect students' learning practices and outcomes. Grounded in a theory-driven abductive methodology, the research draws on data from three empirical studies involving 270 undergraduate students who engaged with the voice-based robot Abii. Data collection methods included student diaries, focus groups, and participant observations, analysed through an integrated approach combining narrative analysis, text mining, and sentiment analysis. The findings reveal that the voice-based robot significantly enhances learning by providing personalised, real-time feedback and facilitating interactive, adaptive experiences. These robots broaden access to resources, extend student engagement, and augment learner agency, resulting in both hedonic and utilitarian value outcomes. By adopting a service-oriented lens, the study contributes to the literature on educational technology, offering fresh insights into how voice-enabled smart nudging can reshape value co-creation processes in education.

Keywords Voice-based robots · Smart nudging · Value co-creation · Educational technology · Student engagement

1 Introduction

When the ethologist Konrad Lorenz [45] started talking to a brood of motherless ducklings regularly, the birds showed signs of sensitisation to his voice and a genuine preference for the human voice [73]. To evoke attention too humans are born with the ability to communicate, primarily through wailing, which during infancy serves to convey their unique wants and states to caregivers. Pittam's [61] emphasis on the importance of voice in social behaviour identifies it as a means to establish bonds among individuals by expressing emotions, attitudes, and personality traits. Educational research further highlights the role of the voice as a social communication tool that significantly influences students' interaction and engagement. For example, educators can convey emotions, enthusiasm, and deep understanding by modulating their voices [78], enabling them to establish emotional connections that make students feel more involved in learning [82].

In such contexts, voice technology applications offer substantial promise [1, 49] as interfaces, intelligent virtual assistants, and conversational agents strive to emulate natural dialogue and meet the growing demand for seamless, intuitive human-machine interaction [19, 33]. Smart service systems with voice conversation capabilities have undergone tremendous innovation in recent years, largely due to significant advances in artificial intelligence (AI) [7, 26, 88]. The sophisticated, data-driven models expand virtual agents' and robots' capabilities in ways that offer clear applications for the educational sector [40]. Intelligent tutors, such as DreamBox, Smart Sparrow, or Knewton, use AI algorithms to analyse student data and recommend personalised lessons and activities, based on each student's learning styles, abilities, and progress. The market for such educational AI has been valued at US$1.82 billion as of 2021. It is expected to grow at a compound annual rate of

✉ Cristina Mele
cristina.mele@unin.it; cristina.mele@unina.it

Tiziana Russo-Spena
russospe@unina.it

Irene Di Bernardo
irene.dibernardo@unina.it

Angelo Ranieri
angelo.ranieri2@unina.it

[1] Department of Economics, Management and Institution, University of Naples "Federico II", Naples, Italy

Published online: 04 December 2025

36.0% by 2030, driven by increasing educational technology investments by private and public sector actors and the expanding reach of education.

In their efforts to simulate human-like communication, educational robots attempt to replicate the nuanced delivery and personalised feedback that human teachers provide [68]. They leverage natural language processing and machine learning algorithms to adapt their responses to students' reactions and learning patterns [84]. Whether manifest as physical entities or virtual avatars, these assistants encourage learners to explore diverse perspectives and broaden their knowledge base [80]. Research into educational robots also reflects interdisciplinary input, with contributions from computer science and education. However, most investigations prioritise technological capabilities and immediate educational outcomes without addressing the broader implications of human-robot interactions for users and their potential for co-creating value. In an educational setting, value co-creation implies that educators and learners engage in reciprocal activities to enhance their mutual growth and development, suggesting the potential for service research to contribute to these discussions as well [28].

There is scant debate on the advantages of integrating robots into educational contexts from a service perspective [49, 52], which constitutes a critical gap in light of ongoing debates about the potential for AI to enhance humans' learning abilities [48, 50]. To determine how voice-based robots affect education beneficiaries and their potential for improving learning practices, we frame learning as a collaborative practice co-created by educators and students, facilitating both the acquisition of knowledge and the ability to understand and apply it. In such a practice, robots' voice capabilities might become a resource that has the potential to contribute to value. We initiate these considerations with a broad research question: *How do voice-based robots affect students' learning practices?*

To answer this question, we undertook empirical research (Dubois and Gadde, 2001) involving the voice-based robot called Abii. Three studies with 270 students provide the basis for a theory-driven abduction process. To interpret the findings, we turn to the nudge theory [71] and the smart nudging framework in service literature [51]. Smart service systems (e.g., educational robots) provide as smart nudges by affecting "people's behaviour predictably, without excluding options or significantly changing their economic incentives" [51], p. 957). By integrating these theoretical lenses with service-oriented perspectives, we can demonstrate how conversational robots, and Abii in particular, can support and improve student learning practices.

Moreover, situating learning as a collaborative, co-creative process between educators and learners allows us to interpret how voice-enabled smart nudging —embodied in educational robots like Abii— materialises in practice. Within this frame, interactions unfold in ways that appear to broaden resource accessibility, extend student engagement, and augment learner agency. Voice-based educational robots offer effective resources for enhancing learning practices by providing personalised, real-time feedback to students, which increases their resource accessibility. They also engage students through interactive, adaptive learning activities, which can help maintain their interest and motivation over time. Finally, voice-based robots can foster a sense of agency among students, encouraging them to take ownership of their learning practices. We specify hedonic and utilitarian value outcomes [44] of using voice-based robots to establish a more comprehensive understanding of their impact on students' learning experiences.

The remainder of the paper is structured as follows. Section 2 reviews the theoretical foundations, discussing learning practices from a value co-creation perspective, the role of educational robots, and the concept of smart nudging. Section 3 presents the research approach, including data collection and analysis. Section 4 reports the empirical findings, illustrating how voice-based robots influence students' learning practices through smart nudging. Section 5 discusses the theoretical contributions of the study, while Sect. 6 outlines its practical implications. Finally, Sect. 7 highlights the limitations of the research and suggests directions for future studies.

2 Theoretical Framework

2.1 Learning Practices: Value Co-Creation Perspective

Traditional education perspectives on teaching and learning suggested a unidirectional process in which knowledge would be transferred from educators to learners. However, more recent approaches, in education as well as organisational theory and service research, propose a more collaborative, co-creative stance [13, 22]. Practice theory emphasises the significance of experiential learning, which can bridge the gap between theoretical knowledge and situated expertise by immersing students in real-life situations, thereby promoting learning and knowing through active participation in hands-on activities and reflection [21, 65]. In this sense, the focus has shifted from the outcome (i.e., knowledge as a noun) to the process of how social practices form and evolve (i.e., knowing as a verb) when agents interact with the world, resulting in a reflective accomplishment [56]. Learning is a practice through which people acquire new knowledge, skills, attitudes, or values; knowing

pertains to their ability to understand, apply, and transfer this acquired knowledge to different contexts.

A practice-based approach can be complemented by value co-creation theories from service research, which predict that value gets collaboratively generated through the active participation of multiple actors [14]. This perspective extends beyond traditional teacher-centred models by positioning students as active participants or co-creators in their educational journeys, who integrate their resources (i.e., skills and capabilities) with institutional resources (i.e., academic facilities, technological infrastructure, faculty expertise, and support services) [36]. Learning emerges not merely from exchanges of knowledge or information but also through dynamic processes, in which both parties actively engage to co-create knowledge and understanding. Thus, learning can be conceptualised as a process of value co-creation [13, 28], in which students' active engagement nurtures the development of knowledge and skills, while empowering them to take ownership of their learning. Engagement also contributes to instrumental (academic performance) and experiential (satisfaction, loyalty) learning outcomes. By actively participating, students can recognise their strengths and areas for growth [70], which, in turn, fosters increased motivation and a deeper commitment to learning—ultimately enhancing achievement and satisfaction [14]. However, meaningful co-creation also depends on learning environments intentionally designed to stimulate engagement and support collaboration among students and between learners and educators. As examples of collaborative practices, peer reviews and discussion forums can enhance learning by allowing students to share their diverse perspectives and insights [76].

Recent advances in learning theory highlight the potential of digital and cognitive technologies to strengthen collaborative educational practices [43]. Human–machine interactions, supported by AI and related tools, can foster autonomous learning and enable personalised pathways tailored to individual styles, paces, and goals through adaptive methods, differentiated instruction, and real-time support [47]. Within this landscape, technology-based solutions have been shown to enhance learners' comprehension and cognitive abilities [46, 50], although most studies to date have concentrated on applications, collaborative platforms, and augmented reality, primarily assessing their impact on learning outcomes [60]. Emerging research on educational robots, however, points to novel opportunities and challenges for co-creation in education. By being embedded in students' learning environments, these robots can encourage interactive, personalised experiences and, as we argue, may further advance value co-creation through smart nudging mechanisms."

2.2 Educational Robots: The Role of Voice

Educational robots are pedagogical or intelligent agents that support learning and teaching [34]. They serve as dynamic facilitators that deliver direct instruction but also promote collaborative peer interactions and amplify student participation [5, 52]. Among interdisciplinary research on educational robots, we note contributions from education, pedagogy, sociology, and computer science. Even though transformative service research also acknowledges the critical role of education and the need to address technologies [59], we find little consideration of how AI and social robots might enhance people's learning abilities [50].

Some studies address the opportunities created by the adoption of educational robots (e.g., [9, 87], describing robots as valuable tools to help teachers by providing distinctive capabilities, such as precision in executing repetitive tasks, flexibility, interactivity, and mimicking humanoid appearance and behavior [87]. Their versatility enables educators to tailor their instructional methods to diverse educational objectives [66]. Another research stream focuses on students and how robots facilitate their learning experiences by providing enjoyable, hands-on activities that foster engagement and interaction [81]. A dynamic approach to learning can enhance students' motivation, capture their interest, and promote improved learning outcomes [3]. In addition, robots are invaluable for cultivating 21st-century skills (e.g., learning, literacy, life skills) [25]; they push students to develop their problem-defining and -solving and teamwork skills [23, 24], such that they become empowered in their learning journey [3].

Researchers also describe various robot types and their functions, from embodied physical robots to virtual alternatives (e.g., [48, 87]), both text-based and voice-based (e.g., [32, 49, 52]). For this research, we focus on voice-based robots designed to engage people through conversation, games, quizzes, or storytelling [35, 67]. The robot's voice provides a potent social signal, and the design of that voice could influence people's emotional responses to and acceptance of the robot [15]. In educational settings, language and direct communication are effective teaching methods [3, 41]. Thus, robots' speaking speed, voice type, and emotional tone affect students' learning performance [20]. Most studies assess the impacts of a range of technical features, including voice humanisation (male vs. female voice), shape (virtual vs. physical), context (24×7 days vs. classroom), and the type of tasks performed (gaming vs. questioning) [20, 67]. Although some studies consider which factors influence the adoption of robots in educational settings [38], including technology user acceptance [42], they tend to elide the specific outcomes of such adoptions. We prioritise understanding the mechanisms of value co-creation

in an educational environment as paramount for improving the quality of educational services. In turn, we propose that robot voice might provide a nudge to engage students and affect their value co-creation practices.

2.3 Smart Nudging

Rooted in behavioural economics [74], nudging theory offers a framework for improving judgments and minimising negative influences [71]. A nudge is a subtle intervention designed to correct cognitive errors and guide individuals toward beneficial choices while still allowing for alternative options. It involves indirect encouragement rather than explicit instruction or enforcement to help people make better decisions than they might otherwise.

In education, nudges are effective in enhancing academic performance and related behaviours [12]. For example, regular updates from teachers to parents about their children's performance significantly reduce dropout rates [39] and increase the frequency of literary activities [83]. In a large-scale experiment, setting goals increased the number of exams completed and improved course performance [10]. Similarly, personalised online nudges based on social comparison positively affect students who place limited importance on grades, resulting in improved end-of-term outcomes [8]. However, most of these studies emphasise short-term behavioural adjustments [62, 63], while giving less attention to sustained learning processes and student engagement [77]. Against this backdrop, the rise of AI as a tool for autonomous, interactive, and self-learning systems capable of performing tasks that traditionally require human intelligence—such as nudging—has sparked growing interest in its educational potential [66, 75]. Although not in an educational context, Mele et al. [51] describe smart nudging, which involves using cognitive technologies to influence behaviour predictably without limiting options or drastically changing economic incentives. These technologies support the design of choice architectures that can (1) augment human capabilities by offering personalised, real-time data for better decision-making, (2) affect emotions by reducing stress and anxiety, and (3) enact social bonds by facilitating connections and collaborations among users. In turn, they can enhance resource accessibility, extend actor engagement, and augment actor agency, all of which foster value co-creation.

Technologies enhance resource accessibility by providing users with real-time data and information that would otherwise be inaccessible. For example, smart wearables and intelligent platforms aggregate and analyse vast amounts of data to offer tailored recommendations and insights. Technologies also extend engagement by creating interactive and immersive environments that keep users continuously involved in their activities. Intelligent tools can personalise interactions and content to reflect users' preferences and behaviours, thereby maintaining their interest and participation over longer periods. Moreover, technologies amplify agency by empowering users to take control of their actions and decisions; AI-driven platforms give users tools to analyse their data, set goals, and track their progress autonomously. However, cognitive technologies alone do not automatically result in smart outcomes; instead, they enhance type-2 nudges [29] and facilitate the creation of a behavioural environment that encourages new practices, leading to impacts on behaviours and outcomes through deliberate judgments and informed choice.

We adopt and apply the smart nudging framework [51] to educational contexts to investigate how students' processes of learning and knowing may be deepened, engagement strengthened, and autonomy supported using smart technologies. Building on the premise that nudges are generally intended to benefit individuals [72], we examine their implications for value co-creation. While acknowledging existing criticisms of nudge mechanisms [69], we focus on their potential relevance in educational settings.

3 Research Approach

With an abductive approach, we conduct data collection, analysis, and pursuit of complementary theories in iterative cycles, alternating among theoretical concepts and field observations to enhance our understanding of the theory and the data [16, 17]. We apply this approach to the introduction of Abii, a smart, physical, voice-based robot, primarily designed for educational contexts. Specifically, the robot can deliver lessons through voice and movement while monitoring student reactions and performance using specified sensors (Table 1), so this setting is appropriate for analysing how this technology can support both students and teachers in the learning process.

We conducted three pilot projects involving 270 students enrolled in different undergraduate management courses (average age of 23 years) over two consecutive academic years, with a balanced representation of female and male participants. The studies encouraged students to reflect on lessons delivered by the voice-based robot and describe their learning experiences. Participants in each pilot project were assigned to complete a lesson with Abii over the course of four distinct phases: fruition, reflection, group discussion, and choral discussion, reflecting a process that moves from individual interactions to group discussions (Fig. 1).

Table 1 Capabilities of abii

	Capabilities	Description
Voice-based robot Abii 	Automation and efficiency	The robot is designed to interact with students independently, without continuous teacher involvement. It provides instant feedback while delivering personalized support and explanation.
	Intuitive interface	The robot comes with an interface designed for easy interaction and accessibility to its features for users.
	User-friendly tone	The robot communicates with users in a friendly and approachable tone, resembling human interaction. It provides positive and negative reinforcement through vocal cues to guide user behavior.
	Generation ability	The robot communicates with users using natural speech by leveraging machine learning algorithms. It delivers content through voice and generates spoken responses.
	Environmental perception ability	The robot has sensors to recognize objects, people, and movement.
	Adaptability	The robot provides individualized support.
	Independence	The robot is designed to operate without an internet connection. This feature ensures that the robot can function autonomously in locations where internet access may be limited or unavailable.

3.1 Data Collection

We collected data with multiple methods across the four phases for each pilot project (Fig. 1). To capture a broad range of perspectives, we employed both individual and collective approaches, engaging students as well as all four researchers.

First, we employed a diary research method [6], a qualitative technique widely used to document unfolding phenomena [30]. Students were instructed to record their interactions and reactions meticulously throughout each project phase. They documented their real-time thoughts and reflections at the end of each lesson involving the Abii robot. These diaries were then digitally transcribed and stored in individual Word documents for subsequent analysis. This method offered rich insights into students ' experiences, allowing us to delve into their thoughts and reflections.

Second, to explore collective perspectives and deepen reflections on how Abii affects co-creation, we conducted focus group discussions, in which we encouraged students to share their thoughts, engage with their peers, and present collective viewpoints, facilitating a critical reflection on their experiences [37, 58, 79].

Third, all four researchers engaged in participant observation, a widely adopted method in qualitative research to gain deeper insights into participants' behaviours, interactions, and experiences [54]. We observed student–robot interactions in the learning setting, noting responses simultaneously for each participant. We conducted 41 observations, averaging 30 min each, resulting in approximately 1,230 min of observation data. In the final collective discussions following each project session, we captured nuanced aspects of the voice-based robot and gained a clearer comprehension of the value co-creation dynamics in each learning environment.

3.2 Data Analysis

To ensure a comprehensive and unbiased evaluation of all these data [11], the analysis involves three techniques: narrative analysis, text mining, and sentiment analysis. First, with narrative analysis, we gain an exhaustive overview of the discourse, designed to understand the underlying

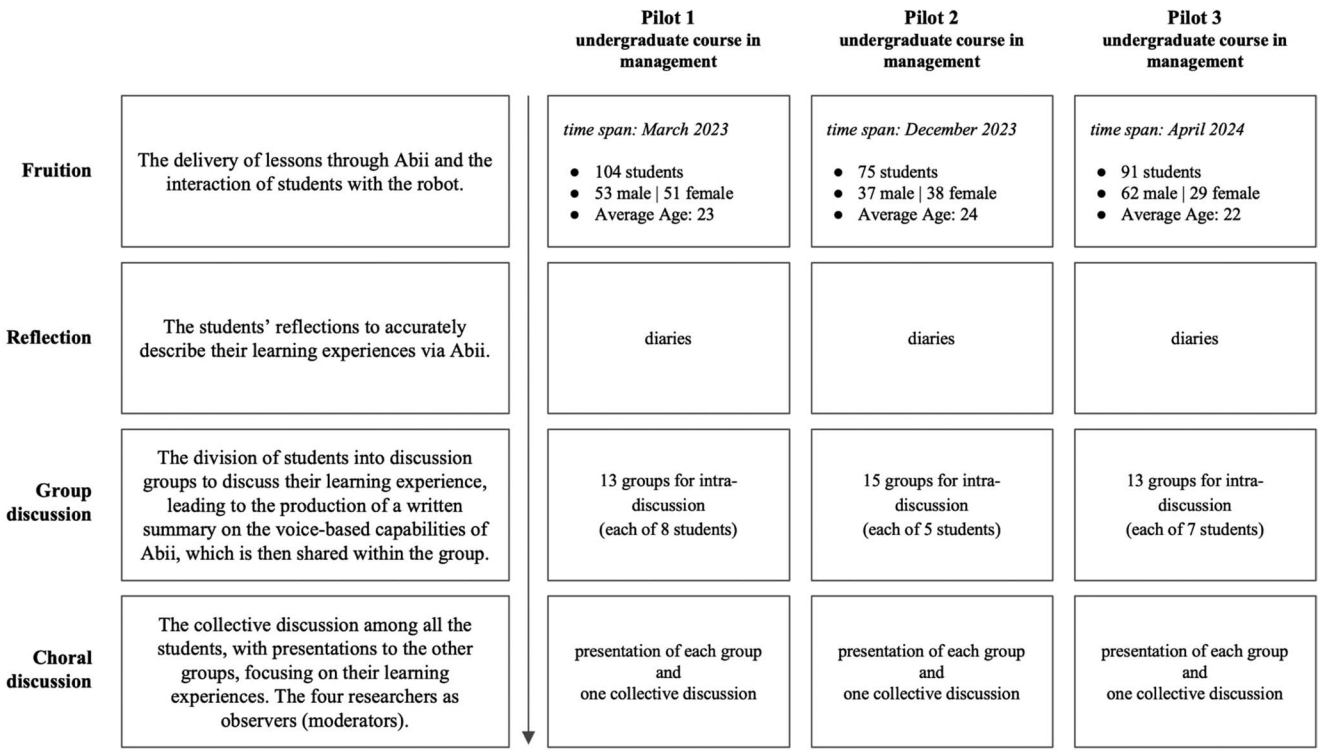

Fig. 1 Pilot study phases

themes, patterns, and meanings embedded in the context and uniqueness of each situation [57]. It involves examining the content and the sequence of events in students' experiences, as recounted in their own narratives, so it contributes to theory development by adding explicit and tacit knowledge [27]. This approach facilitates our identification of preliminary threads and unique insights.

Second, to limit researcher bias, we used ChatGPT-4 to perform a text mining analysis [53, 86]. This tool employs natural language processing and machine learning techniques to analyse textual documents, identify patterns in a structured format, and extract meaningful insights [18, 85]. The text mining process involved several sub-steps, including preprocessing and cleaning the text from students' diaries. Such a process involved removing stopping words and punctuation, and converting everything to lowercase to ensure uniformity. This step is crucial to standardise the text for further analysis. Then, we broke the cleaned text down into individual tokens, or the basic units of the text (e.g., words, phrases), to facilitate a detailed analysis of the text data [2, 4]. Moving on to exploratory data analyses, we conducted a word frequency assessment to identify the most common words used in the text, which included *Abii*, *technologies*, *learning*, *concentration*, *interactive*, *personalised*, *students*, *memory*, *problem-solving*, *creativity*, *engagement*, *independent*, *cognitive*, *potential*, *improvement*, *and learning*. With an N-gram analysis, we also sought to identify common phrases by examining sequences of tokens. This method involves analysing contiguous sequences of n tokens (where *n* can range from 1 to several words) to capture any frequently occurring phrases and patterns within the text [85]. For example, we assess bi-grams (two-word phrases) and tri-grams (three-word phrases) to identify and reveal any common expressions and thematic patterns, thereby gaining deeper insights into how students describe specific concepts. Finally, topic modelling was crucial to our text-mining process. With latent Dirichlet al.location (LDA), we uncover underlying topics within the text segments. This statistical method can identify clusters of words that frequently occur together, thus revealing the main topics discussed across the diaries [2]. According to the LDA, we categorise the text into three themes: (1) instant feedback, (2) encouragement, and (3) reinforcement. Thus, we gain a structured way to understand the primary topics of discussion and the relationships across different themes.

Third, applying text mining with ChatGPT-4, we conducted a sentiment analysis (opinion mining) to determine the overall sentiment of the text segments related to value co-creation achieved through the robot's nudges. With this technique, we extract subjective information from students' responses to identify trends, such as shifts in mood or sentiment. We specifically looked for positive, negative, and neutral sentiments expressed in the text, which we categorised to gauge the emotional tone of the students' reactions

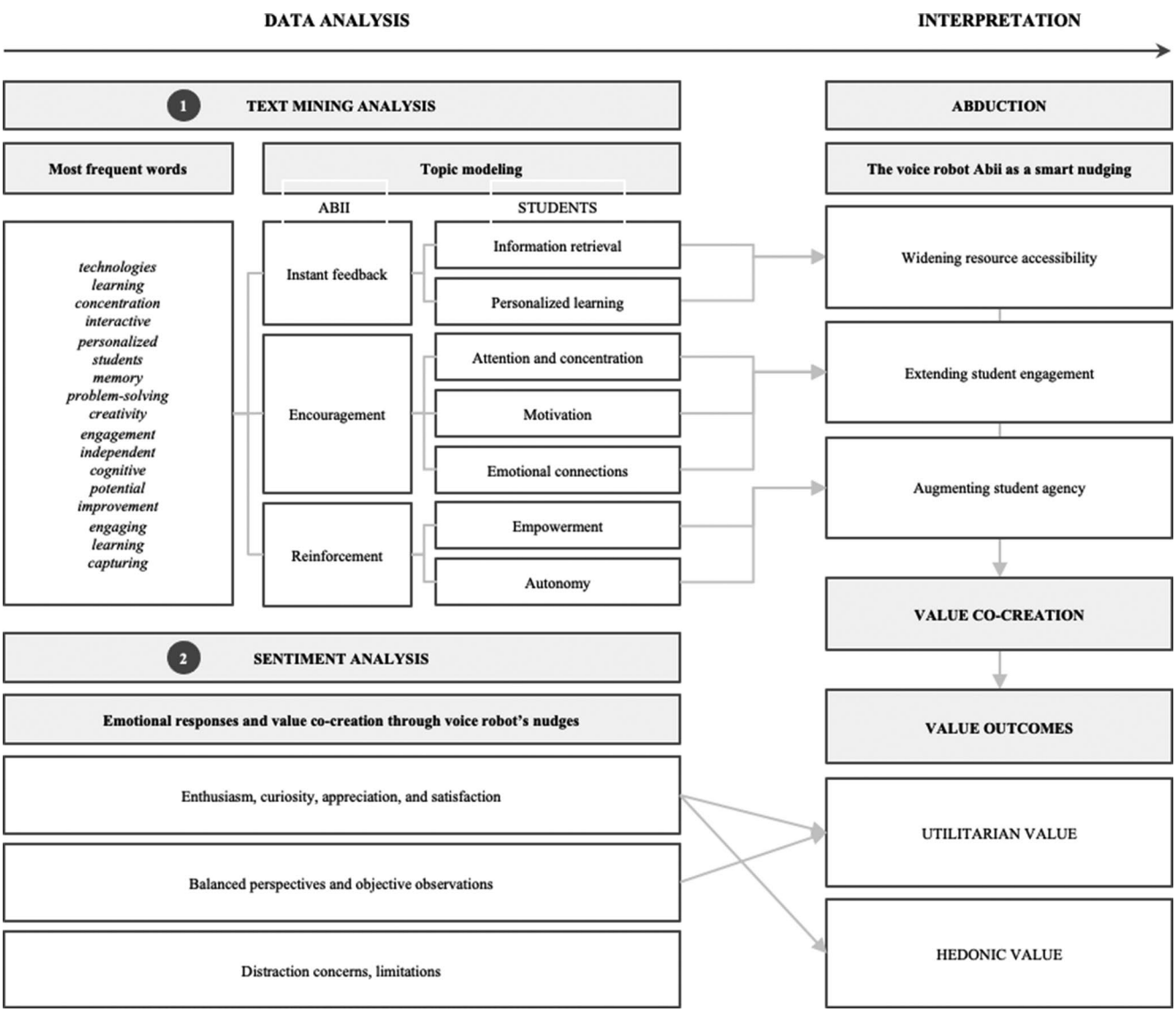

Fig. 2 Data analysis and interpretative framework

Table 2 Sentiment frequency analysis of students' diaries

Sentiment	Examples	Frequency (0–1)
Positive	*Enthusiasm*, *curiosity*, *support*, *engagement*, *and satisfaction*	High (0.6)
Neutral	*Balanced perspectives*, *objective observations*	Moderate (0.3)
Negative	*Distraction concerns*, *limitations*	Low (0.1)

to the voice capabilities of the Abii robot and thereby enrich our understanding of their experiences [55] (Fig. 2). We find that Abii elicits a spectrum of emotional responses, though positive reactions dominate (Table 2). The diaries generally display favourable perspectives on the robot's integration into educational practices, emphasise advantages (e.g., students' curiosity, enthusiasm, satisfaction, and appreciation), and refer to Abii's support and effectiveness. In addition, numerous neutral statements provide factual or informative content, signalling students' balanced perspectives and objective observations, which offer background information or describe the robot's functionalities, particularly its voice capabilities. We also note a few mentions of concerns or drawbacks, such as the robot's inability to replace human teachers completely and the need to rely on other supporting devices (e.g., computer interfaces) (Appendix I). Nonetheless, the overall sentiment suggests that students view the voice-based robot as a beneficial addition to their learning and knowing processes.

To enrich our analysis, we applied a theory-driven abductive approach [16]. Specifically, we connected the three main themes that emerged from the data—instant feedback, encouragement, and reinforcement—with the three choice architectures of smart nudging identified in service

literature: widened resource accessibility, extended student engagement, and augmented learner agency [51]. This analytical step offers a richer, more nuanced perspective on how robots influence (educational) value co-creation practices. The comparison of the automated text mining and analysis also reinforced the reliability of our conclusions and allowed us to validate the findings, identify any discrepancies, and achieve a robust and comprehensive understanding of the data [11, 85].

4 Findings

In the investigated educational settings, Abii functions as a valuable resource, nudging learners toward more engaged and effective practices. By supporting a transition from traditional methods to more dynamic approaches, its advanced speaking capabilities play a central role in this transformation. Through instant and interactive responses tailored to individual learning styles and needs, Abii creates a personalised educational experience. In delivering feedback, encouragement, and reinforcement, the robot facilitates access to resources while promoting engagement and autonomy. In this way, it contributes to the co-creation of learning practices and value outcomes for students. The following sections examine how Abii's nudging mechanisms operate and shape value co-creation.

4.1 Voice-Based Smart Nudges

Abii speaks with students, nudging them toward broader access to educational content, establishing long-lasting involvement with lessons, and amplifying their ability to take charge of their own educational journeys. In line with the smart nudging framework [51], we address three nudging mechanisms in the conversations between Abii and students: widening resource accessibility, extending student engagement, and augmenting learner agency.

4.1.1 Widening Resource Accessibility

Access to wider information and enriched resources that otherwise would be inaccessible is a fundamental aspect through which smart nudging contributes to value co-creation [51]. In our empirical research, we found that voice robot capabilities enhance the ease and effectiveness with which students access, utilise, and obtain resources. Abii provides instant feedback, information retrieval, and personalised learning, such that students can access educational resources through simple voice commands, and the individualised content ensures that the resources they receive are relevant to their specific needs. For example, the robot specifies:

> Hey there! I'm Abii, your smart learning companion. Do you want to explore a new topic or need help understanding one you already know? I'm here to explain whatever you need and provide all the answers you seek. Let's embark on this journey together! (Abii)

Students report preferences for vocal interactions during lessons; they find listening to explanations simpler and more enjoyable than reading text. Simple vocal question-and-answer sessions provide students with real-time feedback, allowing them to immediately clarify any doubts or misconceptions without interruptions or concerns about teachers' availability. The spoken explanations provide clear information to help students grasp the concepts with less effort. Suppose Abii clarifies the lesson topics automatically, without prompting from students. In that case, it also creates a more seamless, intuitive learning experience that reduces the cognitive load on students, enabling them to access information more effectively. Thus,

> Although I initially had low expectations, I was pleasantly surprised. Abii explained the lesson very well, almost like my educator. The lesson was simple and clear, and I understood the topic effortlessly. (Student No. 21)

> Abii is useful to receive answers and clarifications in real time without any delays. During the lesson, I only needed to ask a few questions aloud, and Abii responded immediately and accurately. (Student No. 47)

Many other students explain how the voice-based interactions support ongoing customisation of learning approaches, to reflect their personal efforts. Abii hears students' reactions and keeps track of their performance, then continuously adapts lesson materials and frequently provides tailored recommendations. For example, by breaking down complex lessons into smaller, more digestible chunks, Abii's voice prompts guide students step-by-step through tasks. Students navigate the content at their own pace, reducing the risk of feeling overwhelmed, supporting their comprehension, and facilitating steady progress. They also acknowledge how the customised tone and pacing accommodate their unique learning styles. Whether a student benefits from a slower approach or prefers a quicker, more energetic delivery, Abii adapts to those preferences, thereby maintaining the flow of learning and preventing frustration due to unresolved

questions. Each student receives the most effective learning experience, tailored to their unique needs and preferences:

> Did you get the lesson? If you'd like, I can explain it again more slowly and in detail. Just let me know how you prefer to learn! (Abii)

> Abii listened to us, adapting accordingly, which greatly improved our learning experience. If we mentioned that we didn't understand something, it would repeat the topic at a slower pace. When we asked for more details, it adjusted the lessons to our preferences. This kept us engaged throughout and made it easier to tackle the lesson. (Group discussion No. 10)

4.1.2 Extending Student Engagement

Establishing lasting, motivated interactions [51] and consistent engagement is a critical education goal, necessary for keeping students meaningfully interested and emotionally involved over time. Such outcomes demand more than content delivery; they entail fostering an environment in which students are continuously motivated, and their interests are actively nurtured. With our empirical research, Abii's vocal tones and expressions can instil students' beliefs in their own abilities by emphasising the effort they put in, the progress they have made, and their future potential, rather than focusing solely on outcomes. Abii highlights such efforts by offering encouragement in ways that attract students' attention, motivate their continued learning, and reinforce emotional connections, such as

> Keep it up! It's your persistence and willingness to learn that truly shine. Your potential is limitless. Keep believing in yourself and pushing forward! (Abii)

That is, establishing engagement begins with the critical task of capturing and maintaining students' attention and concentration. This foundational step is essential for encouraging effective learning and facilitating value co-creation in educational settings. Students mention Abii's pivotal role in this process. By using clear, approachable language and instructions, Abii immediately establishes a connection with them; the friendly interaction creates a sense of comfort and readiness, leaving students more receptive to the learning experience. The initial vocal interaction, as requested by Abii, is strategically designed to capture students' attention and set the stage for active participation in the upcoming learning activities. A pre-assessment question serves as a tool to gauge students' prior knowledge but also activate their thinking and curiosity. Students consistently acknowledge how this approach established an interactive, engaging learning environment right from the start, ensuring that they were mentally prepared and motivated to dive into the content of the lesson:

> Hi there! Before we begin our journey together, please take a close look at my camera and monitor and listen carefully to what I say. Be sure to answer the pre-assessment question before we start the lesson! (Abii)

> Abii's vocal questions made us engage more from the beginning to the end of the lessons. We quickly realised the importance of paying attention because a question could arise at any moment. We believe this motivates us to do our best! (Group discussion No. 35)

Once their attention is piqued, Abii's voice capabilities also keep students mentally active, motivated, and invested in the learning process. The robot's ability to respond verbally to their correct or incorrect answers actively stimulated them to continue the conversation. Rather than merely absorbing information passively, students engage in dialogue, which then shapes the course of their learning and deepens their understanding of the lesson content. Abii's interactive nature accordingly transforms the traditional learning dynamic, creating a two-way exchange in which students feel heard and supported. The verbal feedback mechanism corrects misunderstandings in real-time and provides encouragement, which boosts students' willingness to participate. As students anticipate and react to Abii's prompts, they remain attentive and engaged; in other words, they are consistently encouraged to think critically and respond thoughtfully to the challenges presented.

> Awesome work! You've tackled this challenge like a pro. Stay confident and keep pushing forward—you're on the right track! Stick with me, and we'll accomplish amazing results together. (Abii)

> Abii explains and often asks thought-provoking questions. If you provide a good answer, it celebrates your success; conversely, when you answer poorly, Abii seems to react frustrated. Fortunately, Abii continues to support you by providing reassurance and explaining the reason for the mistake. This approach deeply involved me and motivated me to learn and perform at my best. (Student No. 48)

Furthermore, students mention the importance of Abii's supportive and encouraging tone as essential for establishing a strong emotional connection, which then can foster a positive and motivating learning environment. Movements

and gestures represent distinct ways to engage with the learning process; complementing them with voice enhances the communication and creates an even more immersive and enjoyable learning experience. For example, a soothing, gentle tone provides comfort during stressful situations, while an upbeat, lively pitch conveys excitement and happiness. Because it has such voice capabilities, Abii can convey empathy, enthusiasm, concern, or calmness. These emotional expressions encourage students to express themselves more freely and participate in the educational process:

> Fantastic job! Your dedication is clear, and you're making great progress. I'm so proud of you! Keep up the hard work, and remember, I'm always here to support you. Since you've done so well, I'm going to celebrate your achievements with a little dance! (Abii)

> Abii's skillful use of physical techniques, along with his pleasant tone when asking and answering questions, captured our attention and made us feel engaged in the learning process, an experience we also shared with our classmates. (Group discussion No. 8)

4.1.3 Augmenting Learner Agency

Students need the ability to make decisions and exert meaningful control over their learning experience [51]. In our empirical research, we find that Abii's voice capabilities provide reinforcement in a way that pushes students to become more empowered and autonomous learners, capable of navigating educational paths with confidence and purpose. By targeting specific behaviours and consistently applying rewards (positive reinforcement) or removing negative consequences (negative reinforcement), Abii's voice capabilities lead to more empowered and self-directed learning experiences:

> I'm here to help you take control of your learning. By recognising your progress and rewarding your efforts, I aim to support you in becoming more confident and independent in your educational journey. (Abii)

Positive and negative responses empower students to learn from their mistakes and steer their learning in the necessary direction. When they receive positive comments, Abii stimulates their learning process, boosts their confidence, and pushes them to continue putting in effort to improve their skills. A negative response instead functions as a powerful activator of improvement because it is provided constructively. The robot's reinforcement thus spurs them to persist and delve deeper into their studies, which in turn helps students develop resilience and determination, activating their efforts to expand their knowledge and learning skills continuously and without faltering:

> Great job! Your effort and progress are impressive. Keep making those smart decisions and taking control of your learning. You're on the right track, and I'm here to support you every step of the way! (Abii)

> Looks like you've hit a bump in the road. Don't worry—mistakes are part of the learning process. Let's review this together so you can get back on track. Your persistence will lead to improvement, and I'm here to help you succeed! (Abii)

Finally, Abii's responses spurred students to adopt concrete, autonomous actions that could advance their learning process. By proposing choices on the learning path, using a peaceful voice, Abii gives them the autonomy to choose what they want to learn. However, it also guides students by identifying specific areas where they may be making mistakes, which facilitates a crucial first step toward independent correction and improvement. By highlighting these errors with an appropriate tone of voice, Abii helps learners identify gaps in their understanding while also offering tips for overcoming these weaknesses on their own:

> Abii's supportive words gave us the confidence to handle tough topics independently. By pointing out where we need to improve, we were able to self-correct our mistakes. This has greatly improved our ability to manage our own learning. (Group Discussion No. 21)

4.2 Value Co-Creation and Outcomes

Voice-based smart nudging provides gentle, timely prompts or reminders that guide students toward beneficial behaviours. In detail, the widened resource accessibility, extended student engagement, and augmented learner agency achieved through nudging can enhance value co-creation and thereby lead to relevant value outcomes. First, by facilitating seamless access to resources, Abii fosters value co-creation by enabling students to contribute to their learning experiences. With simple voice commands, students can quickly retrieve information and access personalised content, making it easier to find the resources they need. This ease of access removes barriers to educational resources, saves time, and increases learning efficiency. As a result, students can focus more on gaining an understanding of the content:

> With Abii, finding what we need is easy. It's like having a personal assistant for our studies. We just ask, and the information via Abii's voice is immediately available, letting us focus more on learning and less on searching. (Group discussion No. 14)

Second, by enhancing extended engagement, Abii facilitates value co-creation as students maintain continuous participation in the learning process. This consistent encouragement is crucial for maintaining high levels of engagement. Using voice as a medium, the robot captures students' attention more effectively than traditional text-based or visual methods. Sustained interaction with educational materials through reminders, quizzes, and follow-up questions also primes their concentration and motivation. Furthermore, Abii's delivery of emotional messages helps students stay focused and engaged for longer periods:

> Abii's voice reminders and quizzes help us stay motivated and on track, and it's more effective than just reading or watching videos. The encouraging messages also make us feel more connected and focused. (Group discussion No. 37)

Third, by triggering a stronger sense of agency, Abii contributes to value co-creation as students actively shape their learning experiences. The voice-enabled reinforcement enhances students' autonomy in the learning process, enabling them to make more informed decisions about their learning pathways and exercise meaningful control over their educational journeys. As a result, students are better equipped to take charge of their learning, which can lead to improved outcomes and a heightened sense of accountability for their education:

> Abii helps me take control of my learning. In my group, we all agree that its voice support enhances our confidence, allowing us to make better and independent decisions about our studies. This ongoing vocal spur leads to improved results. (Student No. 200)

In using its voice to deliver instructions and encourage and empower students, Abii contributes to co-create learning practices that can produce significant value outcomes. These outcomes entail hedonic or utilitarian value, as indicated by the students' sentiments in relation to the interactions.

4.2.1 Hedonic Value

Hedonic value outcomes refer to the experiential benefits that increase students' enjoyment of the educational process through voice-based robot nudges. Such nudges can support a more engaging and pleasant learning experience, enriching the educational journey with pleasure and emotional fulfilment. As noted, the positive sentiments expressed by students underscore these hedonic benefits, reflected in their curiosity, enthusiasm, and appreciation.

Noting their significant curiosity and enthusiasm toward Abii and its speaking capabilities, students feel a sense of excitement and anticipation. They are eager to explore the lessons facilitated by Abii, often showing increased motivation and a keen interest in participating. This curiosity drives them to ask more questions and engage deeply with the material; their enthusiasm also translates into a livelier and more interactive classroom atmosphere. The novelty of interacting with a voice-based robot like Abii sparks students' imagination, making the learning experience not only useful but also enjoyable and memorable:

> The innovative approach of Abii to integrating voice and movement has revolutionised the way I perceive learning. I approach the subject I'm studying with great curiosity and eagerness! (Student No. 23)

> We anticipate lessons because Abii is full of surprises, which keeps us captivated and involved, all while enjoying the experience together as a group." (Group discussion No. 41)

In turn, students express high levels of appreciation for Abii's effectiveness and interactivity. The robot consistently meets and often exceeds their expectations, making it an asset in educational settings. They praise its ability to transform complex topics into accessible, understandable content, which also enhances their value co-creation process. The positive reception highlights Abii's role in creating a more immersive learning environment, ultimately fostering deeper recognition of educational practices:

> Our expectations were exceeded by the effectiveness of Abii. Its interactive sessions have made complex topics more accessible and easier to understand. (Group discussion No. 45)

> Studying with Abii has become an enjoyable experience that makes me look forward to each study session. It's satisfying to have fun while also deeply and easily understanding the class material. (Student No. 2)

4.2.2 Utilitarian Value

Utilitarian value outcomes refer to practical and functional benefits that improve the efficiency and effectiveness of the learning experience, including tangible, measurable improvements that contribute to educational goals. In this sense, both the positive and moderate sentiments shared by students highlight utilitarian benefits, which also reveal students' balanced perspectives, objective observations, and improvements. Notably, students exhibit a balanced perspective on and report objective observations about Abii's capabilities. The utilitarian value they often cite is the enhancement of learning performance, reflected in both time efficiency and knowledge acquisition. Abii's voice-personalised interactions enable students to reduce their learning time, compared to waiting for scheduled sessions with a teacher, allowing them to achieve their educational goals more quickly. In addition, instant accessibility helps students overcome obstacles, leading to their deeper understanding and retention of knowledge:

> Abii's voice provides instant answers, saving us a lot of time. (Group discussion No. 22)

> With Abii, I optimise my study time. It asks me questions, and if my answers are incorrect, it immediately points out where I need to improve. This saves me time by allowing me to skip over material I already know well and focus on the most critical content. (Student No. 177)

Students express satisfaction with improved learning, time management, and skills development. The robot enhances students' ability to organise their activities and tackle complex tasks with greater efficiency through its voice guidance. The sense of achievement derived from such progress highlights how acquired skills can translate into tangible, measurable benefits, underscoring the importance of investing in refining such capabilities:

> Thanks to Abii's voice prompts, we know what to focus on and which areas need improvement in our studies. This guidance has helped us make study plans and decide what to do first, making our study time more efficient and effective. (Group discussion No. 32)

5 Discussion

This article explores how robots' voice capabilities are becoming valuable resources for co-creating value. Specifically, we ask: *How do voice-based robots affect students' learning practices?* The results provide relevant answers and substantial evidence on how smart service systems (i.e., educational robots) can establish significant benefits through smart nudging, thereby enhancing value co-creation practices. Accordingly, we advance service research in several directions.

First, this study provides a comprehensive empirical evaluation of the voice-based robot Abii with three projects, involving 270 undergraduate students. These studies provide robust evidence of its effectiveness in educational settings [49, 52]. Specifically, the voice capabilities of educational robots enable them to deliver personalised, real-time feedback and adapt to individual learning needs. Students interacted with Abii in various phases—fruition, reflection, group discussion, and choral discussion—and the detailed insights consistently affirm the robot's beneficial impacts on learning practices.

Second, this paper leverages nudge theory [71] and the smart nudging framework in service literature [51] to explore how voice-based robots affect students' learning behaviours and outcomes. Nudge theory, originally rooted in behavioural economics, aims to guide individuals toward beneficial choices without restricting their freedom of choice [74]. Our findings in an education context advance previous literature (e.g., Clark et al. [10, 12] by introducing the concept of voice-based smart nudging and its ability to create interactions that gently steer students toward beneficial learning behaviours and decisions. By assessing the uses of such technologies, this study fills a gap in existing service research. It demonstrates how educational robots can serve as effective tools for smart nudging [51], offering a novel perspective on how voice prompts might improve student learning experiences.

Third, these findings offer novel insights into value co-creation in education. We conceptualise learning as a value co-creation process and thereby emphasise the collaborative nature of educational practices [13, 28]. In turn, our findings provide a new perspective on learning practices, as not merely exchanges of knowledge or information but as dynamic processes in which students actively engage to co-create knowledge and understanding [14]. A voice-based robot can enhance this dynamic by acting as a valuable resource that increases resource accessibility, extends student engagement, and augments learner agency. The robot's voice capabilities facilitate access to educational content, foster continuous interaction, and empower students to take ownership of their learning. By providing real-time

feedback, encouragement, and reinforcement, Abii evokes a more participatory and dynamic learning environment in which students and educators co-create knowledge and understanding.

Finally, our empirical investigation advances service research about the contributions of robots and hedonic/utilitarian values [31, 44, 80]. By categorising the value outcomes of using voice-based robots in education into hedonic and utilitarian types, we add to the understanding of their actual impacts on students' learning experiences. Hedonic value outcomes refer to emotional and experiential benefits, such as increased curiosity, enthusiasm, satisfaction, and overall enjoyment of the learning process. Abii's interactive and engaging nature prompts positive emotional connections with students, such that they find learning more enjoyable and memorable. Utilitarian value outcomes instead pertain to the practical and functional benefits that improve the efficiency and effectiveness of learning, such as enhanced time management, improved knowledge acquisition, and the ability to tackle complex tasks more effectively. By addressing both emotional and practical aspects of learning, we demonstrate that voice-based robots significantly enhance the overall educational experience, making it more engaging and effective for students.

6 Practical Implications

This research on actual integrations of voice-based robots, such as Abii, in educational settings provides new insights for practitioners. First, educational managers should consider adopting voice-based technology to enhance students' access to resources and provide them with personalised learning experiences. The capabilities of voice robots, which can establish tailored interactions with learners and educational materials, enable them to streamline and enrich lesson (content) provision. By integrating voice-based robots into daily educational practices, educators can ensure timely information dissemination and address individual learning needs more effectively, thereby improving their students' learning outcomes, but also optimising their own teaching time and operational efficiency.

Second, voice-based robots help increase students' engagement, which can make teachers' educational practices more effective. We recommend that educators incorporate voice technology into their lesson plans to bolster students' motivation and emotional connection through the promotion of interactive learning processes. By using voice robots to offer support during lessons, teachers can adapt their instructional strategies in ways that address students' needs promptly, in a dynamic and supportive educational atmosphere. Furthermore, leveraging the interactive capabilities of voice-based robots can help foster collaborative learning activities and group discussions, encouraging beneficial social dynamics in classrooms. We thus recommend using voice technology to create more engaging learning experiences, promote active student participation, and maintain students' interest and motivation over time.

Third, education managers should recognise the potential of voice-based robots to empower students to take charge of their own learning. The constructive reinforcement and guidance they provide encourage students to navigate educational paths with increased confidence. This shift toward autonomy moves beyond improving individual learning outcomes; it aligns with broader educational objectives of stimulating critical thinking and self-regulation. School-level strategies and policies should support such transitions, including adaptations to curriculum design and assessment methods to account for the autonomy these technologies promote.

Fourth, education managers can balance different value outcomes. The dual benefits of hedonic and utilitarian value outcomes can be leveraged actively to create a more comprehensive educational experience. Managers should focus on strategies that enhance both emotional and practical aspects of learning, such as using voice-based robots to make learning more enjoyable and engaging while also ensuring the technologies contribute to tangible improvements in learning efficiency and effectiveness. By addressing both aspects, educational institutions can provide more well-rounded and fulfilling learning experiences.

Fifth and finally, adopting such technology requires additional professional development for educators. Educational institution managers should invest in training programs that equip educators with the skills to incorporate voice-based feedback into their teaching practices, so that they know how to interpret the robot's feedback and integrate it into their instructional strategies to support student growth. Providing educators with the necessary tools and knowledge to exploit voice-based robots effectively ensures that the benefits of these technologies can be fully realised. By addressing these areas, educational institutions can enhance their overall effectiveness and contribute to a more dynamic, supportive learning environment.

7 Limitations and Further Research

The findings shed new light on the significant potential of voice-based robots to improve learning practices, but the limitations of this research also create opportunities for further investigation. First, our research is primarily qualitative and limited to a specific context, though it spans three distinct pilot projects. We lack any quantifiable data on

long-term outcomes. Quantitative research could complement the findings and offer more robust evaluations of the effectiveness of voice-based robots, such as longitudinal studies that explore the long-term impacts of integrating the robots into educational settings. Tracking their effects over extended periods can reveal the durability of the observed outcomes and their sustained impact on students' learning processes and achievements. Studying a more diverse range of educational environments and student demographics can also enhance the applicability and relevance of our findings. Specific research questions include: *How do voice-based robots affect students' academic performance over multiple academic years? What are the long-term effects of personalised, real-time feedback provided by voice-based robots on students' learning retention? How does the integration of voice-based robots in diverse educational environments affect the scalability and adaptability of these technologies?*

Second, our study lacks any control groups for comparison, so we cannot generalise the findings or compare the effectiveness of voice-based robots with conventional educational methods. Studies that incorporate control groups and comparative analyses could evaluate how voice-based robots measure up against traditional teaching methods. Exploring a broader range of educational contexts and subject areas can also reveal the generalizability of the findings and provide a more comprehensive understanding of the potential benefits and limitations of voice-based robots. Potential research questions in this stream include: *How does the effectiveness of voice-based robots compare with that of traditional teaching methods in enhancing student engagement and learning outcomes? What differences in student performance and satisfaction can be observed between classes using voice-based robots and those employing conventional teaching approaches? How do voice-based robots perform in different subject areas and educational contexts, relative to traditional methods?*

Third, our results could be influenced by the novelty of the voice-based technology, which could affect the perceived value outcomes. Further research should test explicitly if the benefits are due to the newness of the technology or if they reflect genuine improvements in learning processes. Comparative studies measuring the impact of voice-based robots versus traditional methods, in both the short- and long-term, would provide valuable insights into the relative effectiveness of these interventions. Such studies also examine whether initial positive reactions to the technology diminish over time as the novelty wears off or if the positive impacts on learning practices persist. Another research path could address different design elements of voice-based robots, such as voice tone, interaction style, and personalisation, to determine if they enhance effectiveness in educational settings and thereby reveal some of the mechanisms underlying their impacts on learning. Specific topics for continued research include: *Do the positive impacts of voice-based robots on student learning practices diminish over time as the novelty wears off? How do different design elements of voice-based robots, such as voice tone, interaction style, and personalisation, contribute to their effectiveness in educational settings? What are the short- and long-term impacts of voice-based robots on students' motivation and engagement, compared with traditional methods?*

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s12369-025-01321-7.

Funding Open access funding provided by Università degli Studi di Napoli Federico II within the CRUI-CARE Agreement.

Data Availability The author confirms that all data generated or analysed during this study are included in this published article.

Declarations

Ethical Approval Not applicable.

Competing Interests The authors have no competing interests to declare that are relevant to the content of this article.

References

1. Al Shamsi JH, Al-Emran M, Shaalan K (2022) Understanding key drivers affecting students' use of artificial intelligence-based voice assistants. Educ Inform Technol 27(6):8071–8091
2. Antons D, Breidbach CF (2018) Big data, big insights? Advancing service innovation and design with machine learning. J Service Res 21(1):17–39
3. Atman Uslu N, Yavuz GÖ, Kocak Usluel Y (2023) A systematic review study on educational robotics and robots. Interact Learn Environ 31(9):5874–5898
4. Balducci B, Marinova D (2018) Unstructured data in marketing. J Acad Mark Sci 46:557–590
5. Belpaeme T, Kennedy J, Ramachandran A, Scassellati B, Tanaka F (2018) Social robots for education: a review. Sci Rob 3:1–9
6. Bolger N, Davis A, Rafaeli E (2003) Diary methods: capturing life as it is lived. Ann Rev Psychol 54(1):579–616

7. Brengman M, Willems K, De Gauquier L, Vanderborght B (2023) Media richness effectiveness: humanoid robots with or without voice, or just a tablet kiosk? Psychol. Mark. pp. 1–20
8. Brown MG, Schiltz J, Derry H, Holman C (2019) Implementing online personalised social comparison nudges in a web-enabled coaching system. Internet High Educ 43:1–11
9. Cheng YW, Sun PC, Chen NS (2018) The essential applications of educational robot: requirement analysis from the perspectives of experts, researchers and instructors. Comput Educ 126:399–416
10. Clark D, Gill D, Prowse V, Rush M (2020) Using goals to motivate college students: theory and evidence from field experiments. Rev Econ Stat 102(4):648–663
11. Creswell JW (2013) Research design: qualitative, quantitative, and mixed methods approaches. Sage
12. Damgaard MT, Nielsen HS (2018) Nudging in education. Econ Educ Rev 64:313–342
13. Díaz-Méndez M, Gummesson E (2012) Value co-creation and university teaching quality: consequences for the European higher education area (EHEA). J Service Manage 23(4):571–592
14. Dollinger M, Lodge J, Coates H (2018) Co-creation in higher education: towards a conceptual model. J Mark High Educ 28(2):210–231
15. Dou X, Wu CF, Lin KC, Gan S, Tseng TM (2021) Effects of different types of social robot voices on affective evaluations in different application fields. Int J Social Robot 13:615–628
16. Dubois A, Gadde LE (2002) Systematic combining: an abductive approach to case research. J Bus Res 55(7):553–560
17. Dubois A, Gadde LE (2014) Systematic combining—A decade later. J Bus Res 67(6):1277–1284
18. Feldman R, Sanger J (2007) The text mining handbook: advanced approaches in analysing unstructured data. Cambridge University Press
19. Flavián C, Akdim K, Casaló LV (2023) Effects of voice assistant recommendations on consumer behavior. Psychol Mark 40(2):328–346
20. Gasteiger N, Lim J, Hellou M, MacDonald BA, Ahn HS (2024) A scoping review of the literature on prosodic elements related to emotional speech in human-robot interaction. Int J Social Robot 16(4):659–670
21. Gherardi S (2009) Knowing and learning in practice-based studies: an introduction. Learn Organ 16(5):352–359
22. Gnaur D, Larsen-Nielsen IM (2017) Designing learning for co-creation: conceptual and practical considerations, in Chemi T. (eds) Co-Creation in Higher Education, pp. 225–246, Brill
23. González-Pérez LI, Ramírez-Montoya MS (2022) Components of education 4.0 in 21st century skills frameworks: systematic review. Sustainability 14(3):1–31
24. Gratani F, Giannandrea L (2022) Towards 2030. Enhancing 21st century skills through educational robotics, in Giang, C. (eds), Frontiers. Front Educ. 7
25. Gratani F, Giannandrea L, Renieri A, Annessi M (2021) Fostering students' Problem-Solving skills through educational robotics in primary school. In: Malvezzi M, Alimisis D, Moro M (eds) Education in & with robotics to foster 21st-Century skills. Edurobotics 2021. Springer, Cham, pp 3–14
26. Guha A, Bressgott T, Grewal D, Mahr D, Wetzels M, Schweiger E (2023) How artificiality and intelligence affect voice assistant evaluations. J Acad Mark Sci 51(4):843–866
27. Gummesson E (2017) Case theory in business and management: reinventing case study research. SAGE
28. Gummesson E, Díaz-Méndez M, Saren M (eds) (2022) Improving the evaluation of scholarly work: the application of service theory. Springer Nature
29. Hansen PG, Jespersen AM (2013) Nudge and the manipulation of choice: a framework for the responsible use of the nudge approach to behaviour change in public policy. Eur J Risk Regul 4(1):3–28
30. Helkkula A, Kelleher C, Pihlström M (2012) Characterising value as an experience: implications for service researchers and managers. J Service Res 15(1):59–75
31. Huang MH, Rust RT (2021) Engaged to a robot? The role of AI in service. J Service Res 24(1):30–41
32. Hwang GJ, Chang CY (2023) A review of opportunities and challenges of chatbots in education. Interact Learn Environ 31(7):4099–4112
33. Im H, Sung B, Lee G, Kok KQX (2023) Let voice assistants sound like a machine: voice and task type effects on perceived fluency, competence, and consumer attitude. Comput Hum Behav 145:1–11
34. Johal W (2020) Research trends in social robots for learning. Curr Rob Rep 1:75–83
35. Jost C, Le Pévédic B, Belpaeme T, Bethel C, Chrysostomou D, Crook N, Grandgeorge M, Mirnig N (2020) Human-Robot interaction, vol 12. Springer, Cham
36. Kaminskiene L, Žydžiunaite V, Jurgile V, Ponomarenko T (2020) Co-creation of learning: a concept analysis. Eur J Contemp Educ 9(2):337–349
37. Kemmis S, McTaggart R, Nixon R, Kemmis S, McTaggart R, Nixon R (2014) Introducing critical participatory action research. In: Kemmis S, McTaggart R, Nixon R (eds) The action research planner: doing critical participatory action research. Springer, Cham, pp 1–31
38. Khaksar SMS, Slade B, Wallace J, Gurinder K (2020) Critical success factors for application of social robots in special developmental schools: development, adoption and implementation. Int J Educational Manage 34(4):677–696
39. Kraft MA, Rogers T (2015) The underutilised potential of teacher-to-parent communication: evidence from a field experiment. Econ Educ Rev 47:49–63
40. Labadze L, Grigolia M, Machaidze L (2023) Role of AI chatbots in education: systematic literature review. Int J Educational Technol High Educ 20:1–17
41. Laland KN (2017) The origins of Language in teaching. Psychon Bull Rev 24:225–231
42. Lei M, Clemente IM, Liu H, Bell J (2022) The acceptance of telepresence robots in higher education. Int J Social Robot 14(4):1025–1042
43. Li KC, Wong BTM (2022) Research landscape of smart education: a bibliometric analysis. Interact Technol Smart Educ 19(1):3–19
44. Longoni C, Cian L (2022) Artificial intelligence in utilitarian vs. hedonic contexts: the word-of-machine effect. J Mark 86(1):91–108
45. Lorenz KZ (1937) The companion in the bird's world. Auk 54(3):245–273
46. Mahmud MM, Freeman B, Abu Bakar MS (2022) Technology in education: efficacies and outcomes of different delivery methods. Interact Technol Smart Educ 19(1):20–38
47. McDonald A, McGowan H, Dollinger M, Naylor R, Khosravi H (2021) Repositioning students as co-creators of curriculum for online learning resources. Australasian J Educational Technol 37(6):102–118
48. Mele C, Russo-Spena T (2025) Agencement of onlife and phygital: smart tech–enabled value co-creation practices. J Service Manage 36(2):217–240
49. Mele C, Russo-Spena T, Di Bernardo I, Ranieri A (2025) Talking vs. Typing: how voice- vs. text-based educational robots shape student engagement, J Service Manag 1–24. https://doi.org/10.1108/JOSM-02-2024-0082.

50. Mele C, Marzullo M, Morande S, Spena TR (2022) How artificial intelligence enhances human learning abilities: opportunities in the fight against Covid-19. Service Sci 14(2):77–89
51. Mele C, Russo-Spena T, Kaartemo V, Marzullo ML (2021) Smart nudging: how cognitive technologies enable choice architectures for value co-creation. J Bus Res 129:949–960
52. Mennens K, Becker M, Briker R, Mahr D, Steins M (2025) I care that you don't share: confidentiality in student-robot interactions. J Service Res 28(1):57–77
53. Morgan DL (2023) Exploring the use of artificial intelligence for qualitative data analysis: the case of ChatGPT. Int J Qualitative Methods 22:1–10
54. Musante K, DeWalt BR (2010) Participant observation: A guide for fieldworkers. Rowman Altamira, Lanham, Maryland
55. Nassirtoussi AK, Aghabozorgi S, Wah TY, Ngo DCL (2014) Text mining for market prediction: a systematic review. Expert Syst Appl 41(16):7653–7670
56. Nicolini D, Gherardi S, Yanow D (2016) Introduction: toward a practice-based view of knowing and learning in organisations. Knowing in organisations: a practice-based approach. Routledge, pp 3–31
57. Nie Y (2017) Combining narrative analysis, grounded theory and qualitative data analysis software to develop a case study research. J Manage Res 9(2):53–70
58. Ono Y, Chikamori K, Rogan JM (2013) How reflective are lesson study discussion sessions? Developing an instrument to analyse collective reflection. Int J Educ 5(3):52–67
59. Ostrom AL, Field JM, Fotheringham D, Subramony M, Gustafsson A, Lemon KN, McColl-Kennedy JR (2021) Service research priorities: managing and delivering service in turbulent times. J Service Res 24(3):329–353
60. Papadakis S (2021) Tools for evaluating educational apps for young children: a systematic review of the literature. Interact Technol Smart Educ 18(1):18–49
61. Pittam J (1994) Voice in social interaction, vol 5. Sage, London, pp 1–197
62. Plak S, van Klaveren C, Cornelisz I (2023) Raising student engagement using digital nudges tailored to students' motivation and perceived ability levels. Br J Edu Technol 54(2):554–580
63. Rodríguez ME, Guerrero-Roldán AE, Baneres D, Karadeniz A (2022) An intelligent nudging system to guide online learners. Int Rev Res Open Distrib Learn 23(1):41–62
64. Rosenberg-Kima RB, Koren Y, Gordon G (2020) Robot-supported collaborative learning (RSCL): social robots as teaching assistants for higher education small group facilitation. Front Rob AI 6:1–12
65. Russo-Spena T, Mele C, Nuutinen M (2017) Innovating in practice. Springer International Publishing, Cham
66. Sadeghian AH, Otarkhani A (2023) Data-driven digital nudging: a systematic literature review and future agenda. Behav Inform Technol, pp. 1–29
67. Seaborn K, Sekiguchi T, Tokunaga S, Miyake NP, Otake-Matsuura M (2023) Voice over body? Older adults' reactions to robot and voice assistant facilitators of group conversation. Int J Social Robot 15(2):143–163
68. Selwyn N (2019) Should robots replace teachers? AI and the future of education. Wiley, Cambridge
69. Sunstein CR (2015) Nudges, agency, and abstraction: A reply to critics. Rev Philos Psychol 6:511–529
70. Sykes C, Dean BA (2013) A practice-based approach to student reflection in the workplace during a work-integrated learning placement. Stud Continuing Educ 35(2):179–192
71. Thaler RH, Sunstein CR (2009) Nudge: improving decisions about health, wealth, and happiness. Penguin, London
72. Thaler RH, Sunstein CR, Balz JP (2013) Choice architecture. Behav Found Public Policy 25:428–439
73. Vicedo M (2009) The father of ethology and the foster mother of ducks: Konrad Lorenz as expert on motherhood. Isis 100(2):263–291
74. Vuong QH, Ho TM, Nguyen HK, Vuong TT (2018). Healthcare consumers' sensitivity to costs: a reflection on behavioural economics from an emerging market. Palgrave Commun 4(1):1–10
75. Wagner D (2021) On the emergence and design of AI nudging: the gentle big brother? Robonomics J Automated Econ 2:1–6
76. Wang C, Mirzaei T, Xu T, Lin H (2022) How learner engagement impacts non-formal online learning outcomes through value co-creation: an empirical analysis. Int J Educational Technol High Educ 19(1):32
77. Weijers RJ, de Koning BB, Paas F (2021) Nudging in education: from theory towards guidelines for successful implementation. Eur J Psychol Educ 36:883–902
78. Weinstein N, Zougkou K, Paulmann S (2018) You 'have' to hear this: using tone of voice to motivate others. J Exp Psychol Hum Percept Perform 44(6):898–913
79. Wilkinson S (1998) Focus group methodology: a review. Int J Soc Res Methodol 1(3):181–203
80. Wu L, Fan A, Yang Y, He Z (2021) Robotic involvement in the service encounter: a value-centric experience framework and empirical validation. J Service Manage 32(5):783–812
81. Wu L, Hsieh PJ, Wu SM (2022) Developing effective e-learning environments through e-learning use mediating technology affordance and constructivist learning aspects for performance impacts: moderator of learner involvement. Internet High Educ 55:1–16
82. Yang YTC, Wu WCI (2012) Digital storytelling for enhancing student academic achievement, critical thinking, and learning motivation: a year-long experimental study. Comput Educ 59(2):339–352
83. York BN, Loeb S, Doss C (2019) One step at a time: the effects of an early literacy text-messaging program for parents of preschoolers. J Hum Resour 54(3):537–566
84. Younis HA, Ruhaiyem NIR, Ghaban W, Gazem NA, Nasser M (2023) A systematic literature review on the applications of robots and natural Language processing in education. Electronics 12(13):pp1–26
85. Zaki M, McColl-Kennedy JR (2020) Text mining analysis roadmap (TMAR) for service research. J Serv Mark 34(1):30–47
86. Zhai C, Massung S (2016) Text data management and analysis: a practical introduction to information retrieval and text mining. Association for Computing Machinery and Morgan & Claypool
87. Zhong B, Zheng J, Zhan Z (2023) An exploration of combining virtual and physical robots in robotics education. Interact Learn Environ 31(1):370–382
88. Zierau N, Hildebrand C, Bergner A, Busquet F, Schmitt A, Marco Leimeister J (2023) Voice bots on the frontline: voice-based interfaces enhance flow-like consumer experiences & boost service outcomes. J Acad Mark Sci 51(4):823–842

Cristina Mele PhD is Full Professor of Service Innovation at the Department of Economics, Management and Institutions, University of Naples Federico II. She is delegated of Innovation and Third Mission at University. Her main research interests are innovation and smart technologies, value creation, markets and service ecosystems. She has more than 300 publications. Her articles have appeared in Journal of The Academy of Marketing Science, Marketing Theory, Industrial Marketing Management, Journal of Business Research, Journal of Service Management Journal of Macro Marketing, Industrial Marketing Management, Journal of Business and Industrial Marketing and Journal of Service Theory and Practice. Cristina is one of co-chairs of The Naples Forum on Service. She is the recipient of the Service-dominant logic award (2019), Bo Edvardsson "Industry Impact in Services" Award (2025) and Grönroos Service Research Award (2025)

Tiziana Russo-Spena is Full Professor of Management. She obtained her PhD in management and economics in 2002. Her main areas of interest are innovation management, service innovation, and digital marketing. She has attended several international conferences and co-authored over 100 ref- ereed articles in journals and six books on innovation topics. She has written many articles and books and published in Italian and international journals, including Industrial Marketing Management, the Journal of Business Ethics, and the Journal of Service Management. She is a member of RESER, The European Association for REsearch on SERvices.

Irene Di Bernardo PhD is a research fellow at the University of Naples Federico II. Her research explores how smart technologies reshape human experiences and promote well-being. She has published in leading service journals and collaborates on several projects related to service and social robots.

Angelo Ranieri PhD is a research fellow in Management at the University of Naples Federico II and adjunct professor of Advanced Marketing at the University of Catanzaro Magna Graecia. His research examines how smart technologies transform services and user experiences, with a focus on service robots, conversational agents, and AI-driven solutions. He collaborates on national and international projects exploring service innovation in public and private contexts.