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Reshaping business education: An activity theory analysis of AI teaching assistants

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Abstract

This study examines how an AI-powered teaching assistant was integrated into business courses at the Auckland University of Technology to address the limitations of traditional, large-scale teaching models. Business education increasingly demands flexible and individualised learning support, yet empirical evidence on the pedagogical value of purpose-built AI tools remains limited. Guided by Activity Theory and using an explanatory sequential mixed-method design, this research analysed survey data, semi-structured interviews, and reflective field notes to explore how AI mediated learning, shaped educator and student roles, and influenced academic outcomes. The findings indicate that the AI enhanced engagement, efficiency, and self-directed learning through instant formative feedback, while also easing lecturer workload. However, issues such as inconsistent feedback, limited linguistic adaptability, and institutional integration challenges revealed systemic tensions in AI adoption. The study extends Activity Theory by identifying two new analytical constructs: the community-embedded artefact, where AI acts both as a mediating tool and a social participant in the learning environment, and the spatial misalignment contradiction, highlighting infrastructural frictions between local institutions and external AI providers. These insights contribute to a deeper understanding of AI's pedagogical implications in business education, emphasising the importance of ethical, context-specific integration and sustained human oversight to ensure learning remains meaningful, equitable, and pedagogically grounded.

Keywords: AI, teaching and learning, business education, teaching assistant, activity theory

Introduction

Traditional teaching approaches in business education often rely on standardised teaching methods that may not fully address the diverse learning needs of students. The one-size-fits-all approach assumes uniformity in engagement, comprehension, and learning pace. However, business students enter classrooms with varying levels of prior knowledge, learning styles, and professional aspirations, requiring a more flexible and adaptive approach. As business curricula become increasingly complex and interdisciplinary, the limitations of conventional teaching methods are more apparent.

While lecturers play a critical role in supporting student learning, the increasing demands of larger classes and administrative duties limit their ability to provide individualised feedback, necessitating scalable solutions. This critical gap between pedagogical ideals and practical realities highlights the need for practical, technology-driven approaches that enhance student engagement and academic performance.

Artificial Intelligence (AI) teaching assistants present one such solution by providing real-time feedback and additional learning support beyond scheduled teaching sessions. To explore this potential, we introduced Noodle Factory (NF) AI, an AI-driven teaching assistant, in a business education setting. This research not only examines its role in supporting students but also critically assesses its tangible impact on learning experiences and measurable academic outcomes. However, integrating AI into education raises practical and ethical challenges, particularly regarding technology adoption, transparency, and alignment with pedagogical objectives. Furthermore, the effectiveness of AI tools depends not only on their technological capabilities but also on how well they are integrated into pedagogical frameworks and aligned with institutional goals.

This article explores the role of NF AI as a teaching assistant in business courses at Auckland University of Technology, analysing its impact on learner experience and academic outcomes. Using the Activity Theory as a theoretical framework, the study examines how AI mediates learning processes and reshapes the learning and teaching practices in the educational setting. By critically evaluating both the transformative potential and systemic limitations of AI integration, this article provides insights into how business schools can effectively utilise AI teaching assistants while ensuring meaningful, equitable, and pedagogically sound learning experiences. In addition, this article makes a theoretical contribution to Activity Theory by extending its application to reveal new forms of role reconfigurations and contradictions that remain underexplored in business education contexts.

Literature Review

The integration of AI into education marks a fundamental change in how we teach and learn. While AI's applications span numerous domains, its far-reaching impact on education warrants careful analysis, as these technologies fundamentally transform learning and teaching practices. The following literature review examines the historical development of AI and its revolutionary applications in educational settings, including business education, and synthesises contemporary research to understand its effects on student learning and academic outcomes while highlighting crucial knowledge gaps and disruptive barriers to the adoption of AI.

The Historical Development of AI in Education

The use of AI in education dates back to the 1960s, beginning with early experiments like intelligent tutoring systems (Bond et al., 2024). One of the first AI tools created to explore communication between humans and machines was "Eliza," a simple chatbot that laid the groundwork for future developments (Melo et al., 2024). Over the next two decades, AI systems became more advanced, evolving into Intelligent Tutoring Systems (ITSs) in the 1980s. These systems integrated subject expertise, student assessment, and instructional design, making learning more adaptable and effective.

By the 1990s and early 2000s, AI in education had expanded into new areas, including personalised learning environments that adjusted to individual student needs (Desmarais & Baker, 2012) and tools designed to support group work and collaboration (Dillenbourg & Jermann, 2007). These innovations set the stage for today’s AI-driven approaches to learning and teaching.

In the past decade, rapid technological advancements have driven new applications in education. AI has been used for chatbots to boost student engagement, automated grading systems, predictive tools for identifying at-risk students, and platforms for personalised learning (Bond et al., 2024). However, these developments have also raised important questions about ethics (Holmes et al., 2021), transparency in how AI systems make decisions (Khosravi et al., 2022), and the impact of increasingly independent AI tools on teaching methods (Han et al., 2023).

Today, AI is no longer confined to experimental research – it is a part of everyday classrooms. Tools like ChatGPT, CoPilot, DALL-E and research aids such as Claude and Consensus are changing how we teach and learn. At the same time, the rapid proliferation of AI tools has sparked debates about whether educational institutions are ready for such changes and what AI means for the future of education. These debates highlight the need for clear policies, more empirical research, and professional development to manage the rapid growth of AI in education (Bond et al., 2024).

Benefits of Generative AI Tools in Education

Generative AI tools offer significant advantages for students by personalising learning experiences, improving engagement, and fostering inclusivity. Personalised learning environments powered by AI systems such as ChatGPT adapt to individual learning styles, enhancing motivation and academic performance (Baidoo-Anu & Owusu-Ansah, 2023; Sun & Zhou, 2024). These tools facilitate interactive learning by providing instant feedback, enabling students to refine their understanding and skills in real time (Chen et al., 2022). For instance, AI-driven platforms like Grammarly help non-native English speakers improve their writing skills and build confidence (Nazari et al., 2021).

The accessibility features of Gen AI tools also support equitable learning. Students with disabilities benefit from tailored educational materials, while language barriers are mitigated through tools that offer real-time language assistance (Chan & Lee, 2023; Fichten et al., 2023). Moreover, the anonymity provided by AI tools encourages students to seek clarification without fear of judgment, fostering a more inclusive and participatory learning environment (Chen et al., 2022). Research also shows that students increasingly use Gen AI to enhance communication and productivity, bridging generational gaps in digital literacy (Chan & Lee, 2023).

Generative AI tools also provide substantial benefits for educators by streamlining routine tasks, enhancing teaching methods, and facilitating effective communication. AI-driven systems automate administrative duties such as lesson planning, grading, and feedback generation, allowing educators to dedicate more time to designing teaching activities and student support (Alier et al., 2024; Crompton & Burke, 2023). For example, tools like virtual assistants and chatbots efficiently handle routine queries, reducing workload and ensuring timely responses (Seo et al., 2021).

Incorporating AI into teaching strategies enhances classroom dynamics. Educators can utilise AI to create engaging and adaptive content, including simulations and virtual environments that promote experiential learning (Chen et al., 2020). These tools also align with constructivist principles by fostering collaboration and interaction, bridging the gap between traditional teaching methods and student-centred approaches (Griffiths et al., 2024; McGuire et al., 2024).

However, some educators have raised concerns about overreliance on AI, the potential for plagiarism, and the ethical challenges posed by AI-generated content (Chan & Lee, 2023; Seo et al., 2021; Zhou et al., 2024). Addressing these issues requires the establishment of clear guidelines and targeted professional development to build educators' confidence in using AI tools effectively (Chen et al., 2022; Jain & Raghuram, 2024). Additionally, while AI-driven assessment systems offer consistent and objective evaluations, they must be carefully monitored to ensure they account for the subtleties of student learning and provide meaningful feedback (Wongvorachan et al., 2022).

Although generative AI demonstrates significant potential to personalise and enhance learning, challenges persist, including a lack of robust empirical evidence on its long-term impact and ethical concerns surrounding data use (Alotaibi & Alshehri, 2023).

Gen AI in Business Education

The use of Gen AI in business education is becoming increasingly important in preparing students for an AI-driven workplace. Recent studies show that Gen AI tools can enhance learning, support innovation, and help meet workforce demands. These tools are now widely adopted across different regions, contributing to personalised learning, administrative efficiency, and developing key business skills. Their integration also raises challenges, including curriculum development, ethical issues, and institutional readiness.

Several studies highlight the benefits of Gen AI in improving student learning and creativity. Surugiu et al. (2024) found that Romanian business students used applications such as computer vision, edge computing, and chatbots to receive personalised feedback and engage with interactive content. Similarly, Alfirević et al. (2024) reported that students in Croatia and Bosnia and Herzegovina valued custom-trained large language models (LLMs) for simplifying complex topics. In the UK, Zhou et al. (2024) examined tools like Grammarly and ChatGPT in entrepreneurship programmes, showing that they improved productivity, language skills, and problem-solving. Anjum et al. (2023) explored AI's role in admissions, personalised learning, and administrative processes in Indian business schools. While these studies demonstrate the broad usefulness of Gen AI, they also highlight the need to integrate AI skills into business curricula to better prepare students for evolving industry needs. Additionally, some research points to the limitations of Gen AI in dealing with complex academic questions, calling for more advanced AI systems tailored to business education (Alfirević et al., 2024; Surugiu et al., 2024).

Despite these benefits, using Gen AI in business education has significant challenges. Many studies identify gaps in AI integration within curricula, which are crucial for aligning education with industry expectations (Surugiu et al., 2024; Xu, 2024; Zhou et al., 2024). Additionally, Gen AI tools often struggle with complex academic queries, showing the need for more advanced, business-specific AI applications (Alfirević et al., 2024; Surugiu et al., 2024). Ethical concerns, such as data privacy, algorithmic bias, and academic dishonesty, also present difficulties (Anjum et al., 2023; Zhou et al., 2024). Kalota (2024) warned that overreliance on AI could reduce independent thinking and critical engagement, while Xu (2024) pointed out technical weaknesses, particularly in addressing specialised business problems.

Institutional readiness and resource availability further affect AI adoption. Kalota (2024) noted that while North American institutions benefit from advanced AI technologies, high costs and resistance to change limit widespread use. In contrast, Cano and Nunez (2024) found that Peruvian students used Gen AI in business innovation projects linked to the Sustainable Development Goals (SDGs), demonstrating its potential to encourage creativity and sustainability in resource-limited environments. Additionally, a lack of educator training and theoretical frameworks also poses challenges. Benmamoun (2024) found that many educators struggle to integrate AI effectively due to insufficient training. Meanwhile, Griffiths et al. (2024) called for well-developed teaching models to guide collaboration between humans and AI in business education – an under-researched area.

Research Gap and Current Study

With the rapid proliferation of Gen AI tools in higher education, tertiary institutions have issued numerous preliminary responses. Much of the initial discussion focuses on assessment concerns, leading many institutions to establish AI policies or prohibitions in classrooms. Initially, many imposed blanket bans before adopting more measured approaches, allowing selective AI integration. However, while proponents debate AI's advantages and challenges, these discussions often neglect students' perspectives – the primary stakeholders in higher education. This omission is significant, as including students help fully capture AI's transformative impact (Chiu, 2023; Cooper, 2023; Peres et al., 2023). More qualitative research is needed to explore AI's role in learning, teaching and assessment.

Although empirical investigations increasingly examine commercial AI tools like ChatGPT, Co-Pilot and Gemini, a gap remains in studying purpose-built educational AI applications designed for pedagogy. Existing studies often overlook students' and educators' experiences with these tools. Despite its longstanding use in higher education, Noodle Factory (NF), a purpose-built AI platform, has received minimal scholarly attention. Chiu (2023) highlights the need for empirical research on AI-driven teaching, not just in knowledge acquisition but also in student motivation and engagement.

Ifenthaler and Schumacher (2023) stress the importance of a strong theoretical foundation in AI research to address challenges in human-AI integration. A critical factor in this integration is transparency, enabling stakeholders to assess AI-driven decisions, identify biases, and address ethical concerns. Xu (2024) notes that while AI's impact on STEM fields has been widely studied, business education remains underexplored. More research is needed to determine how AI tools enhance personalised learning and assessment in business education.

Despite global interest in Gen AI, research on its use in New Zealand's business education sector remains limited. Existing studies have examined AI-powered personalised mobile education (Charles, 2023) and AI's broader impact on education (Gander & Shaw, 2024; Kabbar & Barmada, 2023). Research in this area also includes studies on AI in the workforce, such as its influence on soft skills in software professionals (Galster et al., 2023) and sustainability attitudes among Generation Z (Prayag et al., 2022). While these studies provide insights, direct research on Gen AI in New Zealand business schools remains scarce. It is essential to explore how AI enhances business curricula, improves learning outcomes, and addresses unique pedagogical challenges. Although this study is situated in a New Zealand context, its findings offer insights applicable to international education settings facing similar challenges.

As such, this study investigates the integration of the NF AI tool in business education at Auckland University of Technology in New Zealand. Using a mixed-method research design, it examines students' and educators' perceptions of this AI tool in supporting learning and teaching. By focusing on this educational setting, the study seeks to provide deeper insights into Gen AI's benefits while addressing the complexities of its implementation.

A key contribution of this research is the application of Activity Theory as a theoretical framework to explore the interactions and challenges that emerge when using AI in education. Activity Theory provides a structured approach to examining the relationships between AI tools, educators, students, and institutional structures. This theoretical approach offers a robust framework for identifying and analysing the systemic and contextual factors that influence the integration of Gen AI in educational practice.

The article seeks to address the following research question:

How did students and educators perceive and experience the integration of the Noodle Factory Gen AI tool in business education courses?

While the project uses a mixed-method research design, this article focuses on the qualitative data collected from a survey, semi-structured interviews with participants and reflective operational notes.

The Noodle Factory AI

NF AI, developed by a Singapore-based company, is an innovative educational platform designed to enhance learning and teaching practices through AI. Launched in 2018, the platform enables educators to create AI-powered teaching assistants by uploading their existing materials, such as slides, lesson plans, and course notes. This AI tool enables student-course material interactions, providing personalised learning experiences tailored to individual student needs. Key features include instant feedback, adaptive learning paths, and multilingual support aimed at increasing student engagement and improving academic outcomes.

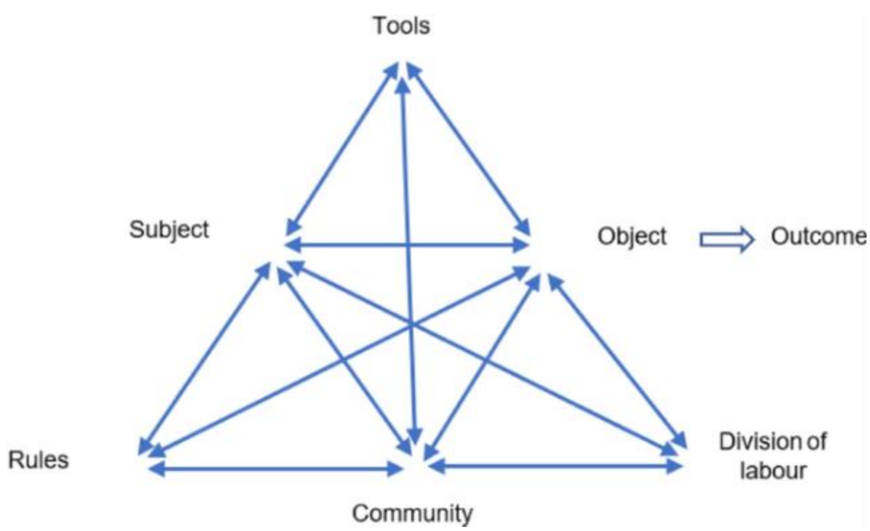
Theoretical Foundation

Activity Theory presents a particularly appropriate analytical framework for conceptualising the complex interactions between students, educators, and AI-mediated learning environments. Activity Theory provides a robust analytical framework for studying human practices at both individual and societal levels (Engeström, 1987; Gedera et al., 2023; Jonassen & Murphy, 1999; Kuutti, 1996; Yakubu & Dasuki, 2021). Rooted in Vygotsky's mediated action theory, it explains how human interactions with the world are shaped by tools, rules, and social structures. The theory is built on two key principles: (1) the human mind develops through interaction with the world, and (2) these interactions are socially and culturally determined (Kaptelinin et al., 1999). Rather than direct engagement, human activity is mediated through artefacts, which can be physical, symbolic, psychological, or virtual (Gedera, 2014; Greenhow & Belbas, 2007).

Engeström's (1987) expanded Activity Theory conceptualises human activity as part of activity systems, which are embedded in sociocultural contexts such as educational institutions. These systems consist of key elements: subject (individual or group), object (goal or purpose), mediating artefacts (tools), rules, community, and division of labour. The interplay between these components influences learning and engagement (Baran & Cagiltay, 2010; Gedera, 2014, 2016; Gedera et al., 2023; Shrestha et al., 2022; Yakubu & Dasuki, 2021). Figure 1 illustrates the basic structure of Activity Theory that underpins this article.

Figure 1

The basic structure of an activity system (adapted from Engeström, 1987)



Activities are dynamic, constantly evolving rather than following a linear progression (Kuutti, 1996). Their development is shaped by historical context, external influences, and systemic imbalances, known as contradictions (Engeström, 2001). These contradictions – manifesting as obstacles, tensions, or conflicts – are crucial for system development and adaptation. Such contradictions may arise within or between elements of an activity system or between distinct activity systems. For instance, introducing novel technology to students may generate tension if technological literacy is insufficient. This might prompt students to question existing paradigms or experience frustration when unable to utilise the new tool effectively (Gedera et al., 2023).

Engeström (1987) identifies four levels of contradictions:

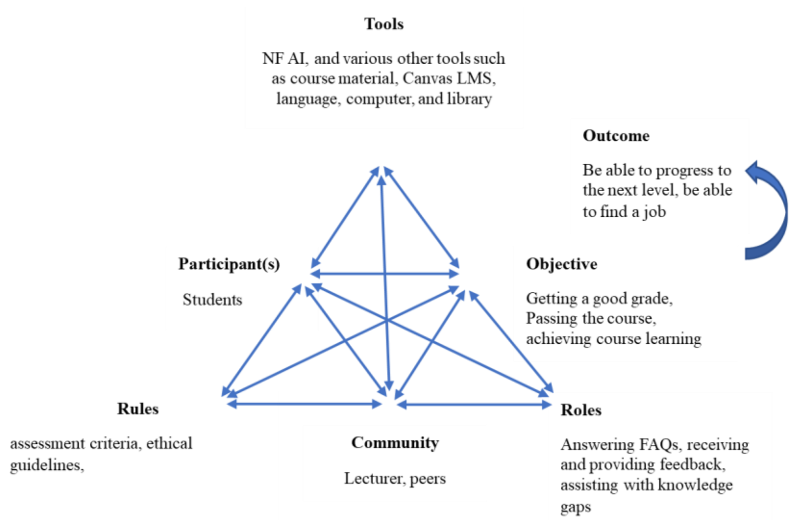
1. Primary contradictions occur within a single component, such as inconsistencies within a community.
2. Secondary contradictions emerge between system components, such as conflicts between students and institutional policies.
3. Tertiary contradictions arise when new tools or methods disrupt existing processes, often requiring adjustments in roles or rules. For example, students unfamiliar with new AI tools may struggle to integrate them effectively (Gedera et al., 2023).
4. Quaternary contradictions occur when an activity system clashes with external structures, such as regulatory frameworks or technological infrastructures. For instance, integrating AI teaching assistants may conflict with university policies.

Understanding these contradictions helps explain how activity systems evolve and adapt, making Activity Theory a valuable framework for examining AI integration in education.

Figure 2 below is an activity systems model developed for the activity of learning with the AI teaching assistant using the Activity Theory framework to demonstrate how an activity can be overlaid in the frame of Activity Theory.

Figure 2

Unit of analysis – learning with the NF AI teaching assistant



Methodology

This study employed an explanatory sequential mixed-method research design to examine students' experiences with NF AI. The research framework consisted of two distinct phases: an initial quantitative data collection phase followed by a qualitative phase, with the first phase informing the design of the second (Creswell, 2014).

The quantitative phase established a broad understanding of students' interactions with the AI platform, while the subsequent qualitative phase enabled a deeper exploration of participant perspectives and experiences. This approach aligns with established mixed methods research principles, which assert that combining quantitative and qualitative data enables researchers to "have a complete understanding of research problems and questions" by "comparing different perspectives drawn from quantitative and qualitative data" (Creswell & Creswell, 2018, p. 216).

This mixed-methods approach provided a comprehensive understanding by integrating quantitative trends with qualitative depth. Prior to commencing the research, appropriate ethical approval was secured through an established institutional ethics committee.

Participants

The participants of this research were undergraduate and postgraduate students enrolled in four business courses, with additional participation from the course lecturer to provide pedagogical perspectives and insights drawn from their reflective operational field notes. The student participant cohort represented diverse ethnic backgrounds, including Pākehā (New Zealanders of European descent), Māori (the indigenous people of New Zealand), Pacific Islands, Asian, and Middle Eastern students. The demographic composition encompassed domestic and international, male and female participants across multiple age brackets, ranging from under 20 to 59 years of age. The data collection included 30 valid questionnaire responses, complemented by nine in-depth semi-structured interviews, which included the lecturer's contribution. The data was further enriched by 42 systematic reflective operational field note entries by the lecturer documenting the pedagogical implementation and emergent dynamics of AI integration across the selected courses.

Methods

The research methods utilised were an online questionnaire, semi-structured interviews, and the lecturer's reflective operational field notes. The study was conducted across four courses spanning multiple semesters in 2024, with three undergraduate courses delivered entirely online and one postgraduate course offered through a blended learning approach. The online questionnaire and interview protocols were developed through the relevant literature review and based on the researchers' expertise in the area of research. Once a draft questionnaire was developed, then it underwent multiple iterations of peer and expert review to ensure validity and reliability.

The questionnaire was anonymous and was structured in two distinct sections. The initial section gathered demographic data, including participants' age, gender, ethnicity, technological access parameters (internet connectivity and device availability) and student status (domestic or international). The subsequent section comprised targeted questions examining students' experiences with the AI learning tool, particularly concerning perceived benefits and challenges. The questionnaire concluded with three open-ended questions designed to elicit detailed responses regarding preferred AI features, the tool's influence on course engagement and outcomes, and potential areas for improvement.

The semi-structured individual interviews facilitated an in-depth exploration of students' interactions with NF AI, focusing on three critical dimensions: platform engagement and user comfort, impact on learning effectiveness and academic outcomes, and utilisation of specific technological features. This qualitative phase enabled a detailed examination of how participants integrated the AI tool into their academic practices, particularly for tasks such as revision and information retrieval. The interviews also investigated potential accessibility barriers and technological adoption challenges. Furthermore, participants were encouraged to reflect on the influence of AI technology on their learning, with specific emphasis on time management efficacy, task completion efficiency, and academic work quality.

The semi-structured interview with the lecturer explored their experiences with integrating the AI tool into the four courses, focusing on objectives, outcomes, and the process of setting up and training the tool. It also examined the tool's affordances, challenges, and overall impact on teaching and learning practices.

In addition to these methods, the lecturer's reflective operational field notes were analysed to provide a complementary perspective on the study. These notes, comprising 42 entries, documented students' engagement with the AI tool, the challenges and learnings associated with its integration, and insights into the capabilities and limitations of the AI tool in the context of higher education. This data offered a valuable lens into the pedagogical implications of the tool's adoption, as well as the refinement of AI integration strategies.

Data Collection and Analysis Procedures

The initial data collection phase centred on quantitative data gathering through a comprehensive online questionnaire. Participant recruitment was facilitated through dual channels: digital communication via the course Canvas (university Learning Management System) platform and a verbal presentation during an established course session. The questionnaire, administered through Qualtrics, was designed to be completed within a 10 to 15-minute timeframe.

The subsequent qualitative phase employed self-selection sampling for semi-structured interviews. Participants indicated their interest in interview participation through a separate contact form appended to the initial questionnaire. Individual interviews were conducted via a video conferencing platform following mutually agreed scheduling arrangements.

The analytical framework followed a systematic approach, beginning with a discrete analysis of the questionnaire data from the first phase. The quantitative analysis protocol commenced with data cleaning procedures to eliminate invalid responses, followed by comprehensive descriptive statistical analysis, including frequency distributions and percentage calculations across demographic variables and questionnaire responses. The qualitative phase served to provide deeper insights into the patterns identified in the initial quantitative analysis.

Upon completion of both phases, all qualitative data, comprising interview transcripts, open-ended questionnaire responses and reflective operational field note entries, were consolidated within the NVivo data management system for systematic analysis. The qualitative analytical process involved iterative reading of textual data to identify emergent themes and sub-themes. Data units pertaining to learning experiences with NF AI were systematically coded according to Activity Theory elements, enabling a theoretically grounded interpretation of the findings.

Findings

This section presents the qualitative findings from survey data, semi-structured interviews and operational reflective field notes from the lecturer on integrating NF AI into business education courses. Using Activity Theory as a framework, the findings are categorised under relevant key components of the activity system: subject-tool mediation, Tool-object alignment, community and division of labour, and rules. In addition, the findings that emerged as issues and challenges with AI integration are also included.

Subject-Tool Mediation

Students and the lecturer perceived NF AI as a valuable educational tool that enhanced learning through three key areas: improved engagement, immediate feedback, and increased productivity. The lecturer affirmed this, stating, "The students that wanted to use it... found it valuable, and that made it worthwhile for me" (Lecturer, Interview).

The AI's personalised guidance helped bridge knowledge gaps and deepen understanding. One student noted, "It made me more engaged and understanding of things I didn't understand" (Student, Survey), while another added, "It helped me draft multiple responses, recognise my weaknesses, and understand the subject more clearly" (Student, Survey). A key strength of the AI was its ability to provide instant, actionable feedback, which supported iterative improvement. A student highlighted, "It only takes 30 seconds to get feedback, and I can use it anytime, even at night. That helped me improve my drafts a lot before submission" (Participant 5, Interview). The lecturer reinforced this, observing, "Students got immediate feedback. It's actionable feedback. So there's always guidance on what they could do" (Lecturer, Interview).

The lecturer’s reflections documented the system's effectiveness through careful observation of student-tool interactions, noting that "Students who engaged with the system revised their submissions multiple times, enhancing the quality of their work through iterative feedback." Students consistently highlighted the efficiency gains, with one survey respondent stating, "The AI enabled me to accomplish my tasks faster, which improved my productivity," and another appreciating the "Fast and easy feedback that NF provided" (Student, Survey).

However, some students experienced inconsistencies in the feedback. One participant observed, "The tool gave me a grade of 90%, but I didn't understand why it wouldn't go higher despite addressing the feedback" (Participant 3, Interview). Another noted, "It's indecisive. You can submit the exact same document twice, and you get different scores" (Student, Survey). The lecturer acknowledged this issue, stating, "Sometimes, the system doesn't know when to stop. It feels obligated to provide feedback, even if the student has already made substantial revisions" (Lecturer, Interview).

Tool-Object Alignment

The findings indicated that NF AI played a supportive role in the learning process, helping students and lecturers achieve their objectives. For instance, a student shared, "It gave me feedback on how to improve... and I saw improvement in the points I got" (Student, Survey). Beyond assessment, the AI’s feedback mechanisms helped bridge gaps in cognitive understanding by directing students towards relevant theories and materials. As one participant stated, “It gave me a framework to work with, recommending theories and course materials I had overlooked” (Participant 2, interview). Another noted, "It helped me link abstract ideas to real-world applications, making the material easier to understand" (Student, Survey).

Students also valued features that supported independent study and revision. One student highlighted the bookmark feature, describing it as a “neat little feature” that “gives a reference on where in the slides you can find” relevant course content. They added, “That's great, because then you can go back into it and have another look” (Participant 4, student interview).

The lecturer observed the broader impact of AI on learning outcomes and conceptual understanding, noting, "The students that responded well to personalised learning... many gained benefits as a result of it" (Lecturer, Interview). This impact was echoed by students, with one commenting, "I think it helped me a lot... I was really happy with my final grade" (Student, Survey). Students appreciated how the AI facilitated their understanding of assessment expectations while deepening their comprehension of the subject matter. One student remarked, “It made revision easier and helped me focus on areas where I could improve, both in my drafts and in my knowledge of the topic” (Student, Survey).

The lecturer also reflected on the long-term benefits of AI for learning and teaching:

Yes, it took a lot of investment and time to get the course set up into NF, but I was invested and interested in doing that with a view that long-term there'd be a return on investment, and it would make a difference to the students' outcomes (Lecturer, Interview).

Community and Division of Labour

The integration of AI restructured the traditional roles within the academic environment, redefining the roles and responsibilities of both students and lecturers. By providing rapid, formative feedback, the AI granted students greater autonomy in their learning while reducing the lecturer's workload. The lecturer emphasised the AI's capacity to deliver rapid, formative feedback, stating, "Feedback was delivered in usually under a minute... I just couldn't compete with that" (Lecturer, Interview). This efficiency was especially beneficial for time-sensitive assessments, allowing students to refine their work independently and iteratively while also applying newly gained insights to their understanding of the subject. One student remarked, "The lecturer wouldn't have time to help everyone individually, but the AI allowed me to spend four hours refining my draft independently and grasping the concepts better" (Participant 3, interview).

For the lecturer, AI facilitated scalability in managing large classes and multiple feedback rounds. "From an educator's point of view, there is just no way that I could provide that kind of feedback within that time frame. Eighty-four students, three rounds of feedback – that's just not possible for me" (Lecturer, Interview). However, the lecturer also reflected on professional expertise, questioning, "If I rely on AI to mark and provide feedback, will I lose these skills?" (Lecturer, Field Notes).

Rules

The ethical use of AI in assessments and learning was another theme that emerged. The lecturer emphasised the importance of guidance, stating, "Part of my job is to show students how to use AI ethically. It's a discussion and guidance process" (Lecturer, Interview). This aligns with students' awareness of academic integrity, as one remarked, "I knew I had to do my own work... to avoid plagiarism" (Student, Survey).

AI-driven feedback also raised concerns about equity. The lecturer observed that "it is the students working in the c-range to b-range of assessment grades who are gaining more advantage from NF marking" (Lecturer, Interview), suggesting that certain student groups might benefit more than others. This implies that AI tools may benefit certain students more than others, influenced by their design, functionality, and alignment with the activity's objectives and rules.

The lecturer further noted tensions between AI-assisted grading and university policies: "Will students ask for their work to be graded by AI?" (Lecturer, Field Notes). This reflects the broader debate over AI’s role in assessment and institutional resistance to AI-driven grading.

Challenges and Issues

Challenges in integrating AI included technical limitations, inconsistent feedback, and institutional constraints, highlighting the complexities of adopting and optimising innovative tools within contemporary educational settings.

The lecturer highlighted system unavailability during critical assessment periods, compounded by New Zealand’s time zone differences, often requiring early issue identification before vendor support became available. "New Zealand is sometimes referred to as the country that first sees the sun each day" (Lecturer, Interview), underscoring the lecturer’s role in mediating between students and technical support.

Institutional decisions significantly influenced the efficacy of the AI tool in facilitating student learning and academic outcomes in this context. While initial integration with the Canvas Learning Management System was supported for one course, further integration was suspended due to the need for clearer technological protocols at the institution. The lecturer acknowledged this impact, stating, "The efforts of incorporating AI have made a positive difference in student learning outcomes, but integration into processes needs to be thought through more clearly" (Lecturer, Interview). Students echoed this, with one commenting, "If it were embedded directly into Canvas, it would feel more natural and accessible" (Participant 5, Interview). The lecturer emphasised the importance of streamlined integration: "It's absolutely vital to have one or two clicks, vital to have single sign-on" (Lecturer, Interview).

Additionally, AI interaction with non-native English speakers posed challenges. One student noted, "Sometimes it didn’t understand questions with minor errors or less formal phrasing" (Participant 3, Interview), suggesting potential disadvantages for students whose inputs deviated from standard linguistic norms.

Discussion

This section discusses the findings through the lens of Activity Theory, examining how the integration of NF AI in business education interacts with key components of the activity system, including subject-tool mediation, tool-object alignment, community roles, and rules. It also discusses systemic tensions and challenges that emerged as contradictions within this framework. This approach allows for a nuanced understanding of the socio-cultural dimensions influencing the adoption and efficacy of the tool.

Subject-Tool Mediation: Dynamic learning process

A core principle of Activity Theory is tool mediation, where tools facilitate interactions and help transform an object into an outcome (Kaptelinin, 1996). These mediating tools – whether physical, psychological, cultural, symbolic, or virtual (Gedera, 2014) shape learning. In the context of our study, the findings revealed that the NF AI functioned as a critical mediating tool in facilitating student learning processes.

The affordances of this virtual tool extended significant benefits to both students and the lecturer, thereby illustrating the dynamic interplay between human agency and technological mediation. Specifically, the tool's mediation supported deeper cognitive engagement and cognitive development, enabling students to internalise complex subject matter with greater efficacy.

The facilitative role of the AI tool aligns with Vygotsky's Zone of Proximal Development (ZPD), which highlights the gap between what learners can achieve independently and with guidance (Vygotsky, 1978). Its ability to provide immediate feedback and clarify misconceptions in real-time supports students' progression toward mastery. The tool's 24/7 accessibility further strengthens its role as a scaffold, allowing students to receive tailored support at their own pace, reinforcing self-regulated learning and learner autonomy – key tenets of constructivist learning theories.

By offering highly personalised learning experiences (Baidoo-Anu & Owusu-Ansah, 2023; Chen et al., 2020; Surugiu et al., 2024), the AI enabled students to ask questions, receive instant feedback, and address knowledge gaps anytime, fostering self-directed learning and greater ownership of their education. This active engagement promoted motivation and deeper learning (Garcia-Martinez et al., 2023).

From a constructivist perspective, the AI supported an inquiry-driven learning environment, where students actively co-constructed knowledge rather than passively consuming information. While AI is a digital tool, it still mediates social dimensions of learning by fostering meaningful student-AI interactions akin to human tutoring. The instant, actionable feedback redefined student-coursework interaction, enabling iterative refinement of understanding and a dynamic, responsive learning experience (Baidoo-Anu & Owusu-Ansah, 2023). This shift bridges traditional teaching methods with interactive, constructivist approaches (McGuire et al., 2024) and highlights the transformative role of AI in reshaping subject-object relationships within activity systems (Engeström, 2001).

Additionally, the AI enhanced instructional support by synthesising student performance data and identifying common learning gaps, enabling more targeted interventions. By reducing the lecturer's logistical burden, the tool improved the monitoring of student progress and contributed to a more effective learning experience for both students and educators.

However, as with any mediating tool, contradictions emerged in the system. These challenges will be explored in the final section of the discussion, considering their broader implications for AI-mediated pedagogy.

Tool-Object Alignment: Enhancing Learner Engagement and Outcomes

Activity Theory conceptualises learning as an activity system where tools mediate the relationship between the subject (students) and object (enhanced engagement and academic outcomes) (Engeström, 2001). The findings indicated that NF AI played a crucial role in aligning students' learning processes with their academic goals, demonstrating how AI fosters engagement (Garcia-Martinez et al., 2023), deepens cognitive understanding, improves academic performance (Sun & Zhou, 2024), and enhances efficiency and productivity (Chan & Lee, 2023; Zhou et al., 2024).

A key outcome observed was the AI's role in refining students' understanding of course-material and assessment drafts. From an Activity Theory perspective, this aligns with object transformation, where tools help learners progress from partial understanding to structured, knowledge-rich engagement. The AI's targeted, iterative feedback allowed students to identify areas for improvement and enhance the quality of their work over time.

The AI also streamlined revision and assessment preparation, increasing student productivity. By delivering rapid, personalised feedback and directing students to relevant theories and resources, the AI reduced unproductive effort, allowing them to focus on high-impact learning areas. This reconfiguration of learning workflows shifted students' cognitive effort from navigating content aimlessly to engaging in meaningful, outcome-driven learning (Chen et al., 2020).

Beyond student benefits, the AI also reshaped the lecturer's role, reflecting Activity Theory's principle that tools reconstitute educational practices and cognitive processes. The AI improved operational efficiency by automating feedback processes (Seo et al., 2021), reducing traditionally time-intensive tasks while ensuring consistency and timeliness. This allowed the lecturer to shift focus from administrative tasks to more pedagogically valuable activities, such as designing enriched learning experiences and engaging in meaningful student interactions. The tool's scalability was particularly beneficial in large student cohorts, ensuring all learners received timely, personalised feedback regardless of class size.

While AI-mediated learning enhanced efficiency, productivity, and academic outcomes, contradictions emerged in the system. These tensions in tool-object alignment will be explored further under Contradictions.

Community and Division of Labour: The Shifting Roles

Activity Theory emphasises that learning occurs within a socially mediated system, where roles, responsibilities, and interactions evolve in response to new tools and technologies (Engeström, 2001). The introduction of NF AI significantly restructured the division of labour in the educational setting, redistributing responsibilities among students, lecturers, and the AI itself.

The AI-enabled feedback increased student autonomy (Hidayat-ur-Rehman, 2024) while reducing the lecturer's traditionally time-intensive feedback workload, altering the dynamics of the academic community. This reflects the transformative impact of tool mediation, where technology not only supplements but reshapes roles within the activity system (Engeström, 2001).

A key finding was the shift towards self-regulated learning, as students engaged in independent revision cycles with immediate, iterative feedback, requiring less direct lecturer intervention. This shift positioned students as more active agents in their learning, aligning with Engeström's concept of expansive learning, where learners assume new responsibilities in response to systemic transformation (Engeström, 1987).

Simultaneously, the lecturer's role evolved from primary feedback provider to strategic facilitator. Traditionally, educators manage both content delivery and assessment feedback, but automated formative feedback allows lecturers to redirect cognitive and instructional resources towards higher-order pedagogical tasks (Burner, 2025).

One of the most pronounced shifts in the division of labour was AI's role in addressing scalability challenges in large classrooms, particularly under heavy workloads (Venter et al., 2024). In conventional settings, providing individualised, iterative feedback to large student cohorts is often logistically unfeasible. The lecturer reflected that handling 84 students in one course across three rounds of feedback would be impossible without AI, highlighting how automation transformed feedback from a bottleneck to a scalable, sustainable support system. This expansion aligns with Activity Theory's principle of systemic transformation, where tools enable new modes of engagement (Engeström, 2001).

Beyond individual role shifts, AI also reshaped broader academic community dynamics. Traditionally, feedback sessions are central to student-lecturer engagement, serving not just as corrective guidance but also as opportunities for mentorship and cognitive scaffolding. With automated feedback delivery, students increasingly engaged with AI rather than human instructors in formative learning stages.

This dual positioning of NF AI as both a mediating tool and an embedded member of the classroom community illustrates what we term a community-embedded artifact (or tool). In this role, NF AI did more than facilitate interactions between subjects and objects – it actively participated in the social and pedagogical environment, influencing norms, expectations, and patterns of interaction within the learning community.

An unexpected finding of the study was students attributing 'personality' or agency to the AI when it provided inconsistent feedback. This emotional response influenced their trust in the tool, revealing that even well-trained AI may be interpreted in relational ways, particularly when used in assessment.

While this expanded accessibility, efficiency, and productivity, it also reduced direct lecturer-student interactions (Sio et al., 2021). Activity Theory highlights how AI shifts knowledge mediation, transforming student-lecturer interactions. While AI improved efficiency and accessibility, it also raised questions about the role of human connection in the learning process (Sio et al., 2021). Does reduced lecturer-student engagement weaken relational and motivational aspects of learning? Or does it allow lecturers to engage in more meaningful, targeted interactions rather than spending time on repetitive feedback cycles?

While AI redefined the division of labour, it also introduced new contradictions within the academic community. These challenges will be discussed later in this section.

Rules: The evolution of rules with AI

Activity Theory emphasises that rules within an activity system regulate interactions between subjects, tools, and objects, shaping the boundaries of engagement within an educational context (Engeström, 2001). The integration of NF AI in this study reshaped the regulatory aspects governing student learning, ethical engagement and assessment protocols. This finding highlights how institutional policies, ethical guidelines, and implicit norms surrounding AI use in education are evolving, creating both opportunities and tensions within the activity system.

The emergence of ethical considerations in AI-mediated learning environments represents a significant evolution in educational rule systems. The findings illuminate how the integration of AI technologies necessitates the development of new ethical frameworks that extend beyond traditional academic integrity protocols (Bond et al., 2024).

A key shift is the reconfiguration of ethical norms in student learning and assessment. Traditionally, academic integrity policies have emphasised originality and individual effort, with plagiarism policies serving as primary regulatory mechanisms (Bretag et al., 2019). However, AI's role in feedback, drafting, and conceptual support introduces complexities that require expanded guidelines (Bond et al., 2024). Despite these challenges, students acknowledged their responsibility for originality and academic integrity, suggesting that AI has not weakened ethical considerations but instead reframed them within a self-regulated model.

The differential impact of AI-driven feedback on student performance brackets, particularly benefiting those in the C to B grade range, reveals how technological mediation can reshape established assessment norms. This finding suggests that rules governing AI engagement may unintentionally favour certain learner groups, raising concerns about algorithmic bias and fairness (Zhou et al., 2024). Consequently, targeted interventions are needed to address disparities in AI effectiveness across different performance levels, ensuring that feedback mechanisms support all students equitably.

The identified paradox between institutional assessment protocols and AI-driven assessment practices represents a classic contradiction within activity systems. This contradiction will be discussed in detail in the next section.

Challenges and Issues: Turning Systemic Contradictions into Development Opportunities

Through the lens of Activity Theory, contradictions arise as conflicts, challenges and inherent tensions in activity systems, prompting adaptations that lead to long-term development (Engeström, 1987). These contradictions manifest across different levels within the activity system, ranging from internal tool-related tensions to wider institutional and infrastructural misalignments. The sections below discuss the contradictions that emerged in the current study.

Primary Contradictions: Automation vs. Adaptability in AI Feedback

Students appreciated AI's instant feedback on draft assessments. However, moments of misalignment were also observed, resulting in a primary contradiction within the activity system. The tool's feedback occasionally failed to fully address individual expectations with their drafts, with some students reporting inconsistency or indecisiveness in recommendations (Burner, 2025). This is due to AI's reliance on predefined models limiting its ability to interpret nuanced academic writing, making feedback less adaptable to individual learning contexts (Surugiu et al., 2024).

Moreover, AI struggles with subtle assessment nuances (Wongvorachan et al., 2022) and is prone to factual inaccuracies and algorithmic bias (Cao et al., 2025; Chan & Lee, 2023). These tensions highlight the complex interplay between automation, adaptability, and learner expectations in AI-mediated learning environments. For AI to serve as an effective mediating tool, ongoing algorithmic refinements are necessary to enhance context-aware feedback and better support diverse student needs.

Through the lens of Activity Theory, the linguistic accessibility challenges of NF AI also reveal a primary contradiction within the activity system, particularly affecting non-native English-speaking students. Some students reported that minor phrasing errors or informal academic expressions led to misinterpretation or rejection of responses by the AI tool, creating barriers in the subject-tool interaction. This contradiction reflects a disconnect between AI's language-processing capabilities and the diverse linguistic realities of students, reinforcing the need for adaptive AI models that can process non-standard English inputs while maintaining accuracy and inclusivity.

Secondary Contradictions: The Shifting Role of the Educator and Pedagogical Authority

The automation of formative assessment feedback restructured the traditional division of labour within the learning environment, leading to secondary contradictions concerning the evolving role of the lecturer. Lecturers have traditionally been the primary providers of assessment feedback, guiding students through formative learning cycles while offering expert judgment. However, the integration of AI-mediated feedback has redistributed these responsibilities, freeing educators from routine grading tasks while also raising concerns about the erosion of pedagogical authority and expertise retention.

The lecturer's reflection – "If I rely on AI to mark and provide feedback, will I lose these skills?" – captures this tension, reflecting a broader uncertainty about the long-term impact of AI dependence on pedagogical expertise. Burner (2025) emphasises that while AI can enhance efficiency and accessibility, its overuse risks diminishing human educators' engagement with students' cognitive development, potentially weakening mentorship and individualised support. This contradiction highlights the challenge of maintaining a balance between automation and human-centred pedagogy, requiring institutions to reconsider the lecturer's role not just as an AI supervisor but as a strategic facilitator who ensures AI-human collaboration enriches the learning process rather than replacing its core human elements.

Tertiary Contradictions: Institutional Resistance to AI in Assessment

The tension between institutional assessment protocols and AI-driven assessment practices exemplifies what Engeström (1987) terms tertiary contradictions. These tensions occur when a new model or innovation is introduced into an activity system but clashes with pre-existing practices, norms, or expectations. The lecturer's rhetorical question – "Will students ask for their work to be graded by AI?" – reflects an underlying clash between technological advancements and established academic assessment policies. While students have grown accustomed to AI-mediated feedback, universities remain resistant to automated grading, citing concerns over assessment fairness, potential biases, and the limitations of AI in evaluating complex, subjective work.

Although AI offers scalable and efficient grading mechanisms, universities continue to emphasise the importance of human evaluative judgment, particularly in disciplines that require critical analysis, creativity, and subjectivity in assessment. Addressing this tension requires institutions to explore hybrid grading models, where AI assists in formative assessment, but final grading retains human oversight, ensuring academic integrity, rigour and efficiency.

Quaternary Contradictions: Systemic and Technical Challenges in AI Integration

The integration of the NF AI within broader institutional systems revealed quaternary contradictions in the context of our study. A notable contradiction emerged due to the lack of full LMS integration, which limited student direct access to AI-generated feedback. While the AI tool was designed to enhance learning, its partial implementation across courses, driven by the institution's need to establish comprehensive integration protocols (new rule), created a structural tension that directly impacted students' engagement with learning with the AI tool. This tension highlights how institutional policies and technical infrastructure decisions fundamentally affect technology integrations, suggesting that successful tool mediation depends not only on technological capability but also on systematic institutional alignment, including support structures.

Additionally, the geographical positioning of the institution in New Zealand emerged as a distinctive mediating factor, creating temporal misalignment between local operational needs and vendor support availability. This spatial misalignment contradiction exemplifies a quaternary contradiction arising between the central activity system and its neighbouring systems. Within the activity system's community component, the lecturer's role proved instrumental in mediating between the subjects (students) and the tool. As a key community member, the lecturer's position exemplifies what Activity Theory describes as the mediating influence of the community on subject-tool interactions.

These contradictions illustrate the broader structural and technological challenges shaping AI's role in learning. However, contradictions are not merely obstacles; they are intrinsic to system development, acting as catalysts for transformation (Engeström, 2001). Contradictions – whether within a single component or across multiple systems – drive adaptation and refinement in educational practices (Engeström, 1987).To fully harness AI's potential, institutions must mitigate technical barriers, ensure equitable access, and align AI-driven learning with educational priorities, transforming contradictions into opportunities for development.

Theoretical Contributions

This study not only applies Activity Theory as an analytical lens but also advances the theory by challenging the traditional boundaries between its core components. While it does not alter AT's foundational constructs, it demonstrates contextual extensions of contradictions and role configurations that have not been widely explored in prior research – most notably, the division between tool and community. In this study, the NF AI teaching assistant clearly functioned as a mediating artifact, providing formative feedback, guidance, and access to course content. However, it also assumed socially embedded roles, with students and educators referring to it in interpersonal and pedagogical terms, treating it not only as a functional tool but as an integral participant in their learning interactions. To capture this dual role, we propose the construct of a community-embedded artifact: an AI system that simultaneously mediates activity and participates in the sociocultural environment that shapes that activity. This positioning challenges conventional AT compartmentalisation and reflects the growing complexity of sociotechnical systems in contemporary education.

The dual status of NF AI had cascading effects on other components of the activity system. Its ability to take on educator-like responsibilities – particularly in delivering scalable, iterative feedback – reconfigured the division of labour, while also influencing evolving rules and ethical practices within the classroom. Additionally, this study identifies a novel systemic tension: a spatial misalignment contradiction. This occurred where institutional reliance on a cloud-based AI platform, developed and supported in another country, introduced temporal gaps in responsiveness and problem resolution – particularly around urgent assessment deadlines. We propose this as an addition to quaternary contradictions within AT, emphasising infrastructural and temporal frictions between co-dependent activity systems such as educational institutions and external AI vendors. By foregrounding these two theoretical contributions – the concept of community-embedded artifacts and the identification of spatial misalignment contradictions – this study extends AT's capacity to account for the complexities of AI integration in education.

Implications and Conclusion

The findings of this study directly answer the research question: How did students and educators perceive and experience the integration of the NF GenAI tool in business education courses? The results indicate that NF AI was perceived as a valuable educational tool that enhanced engagement, provided immediate feedback, and improved learning efficiency. Students appreciated the AI's ability to personalise learning and facilitate independent study, while educators recognised its potential to scale formative feedback and streamline teaching processes.

In addition to reinforcing known benefits of AI such as feedback efficiency and engagement, this study identifies lesser-documented findings: (1) students' critical reflections on AI as a co-participant rather than a tool, (2) perceived inconsistencies in automated scoring, and (3) the impact of institutional resistance and infrastructure on learning efficacy. These add to the growing empirical base on AI in education. These insights contribute to a nuanced understanding of how AI teaching assistants reshape learning and teaching in business education, highlighting both their transformative potential and the need for strategic, ethical and pedagogically sound integration.

Integrating AI teaching assistants in business education requires careful alignment between technology and pedagogical objectives. As generative AI becomes embedded in professional practice, universities must equip students with the competencies to engage critically and ethically with these technologies. AI literacy – spanning responsible use, transparency, and an understanding of AI's limitations – is essential for informed learning. Business education, which prioritises critical thinking, requires AI tools that enhance rather than replace student effort and educator guidance.

From a theoretical perspective, this research applied Activity Theory to examine the interplay between AI, learners, educators and institutions. By situating AI within an evolving activity system, it identified contradictions – such as tensions between automation and adaptability, efficiency and pedagogical depth – that influenced AI's role in higher education. These contradictions highlight both opportunities and risks, reinforcing the need for institutional policies that ensure AI serves educational goals rather than administrative convenience.

This study also raises ethical concerns, including data privacy and algorithmic bias. AI tools must uphold university standards for security, fairness, and inclusivity, ensuring equitable access and mitigating unintended consequences. While AI can enhance education through personalised support, human expertise remains essential in maintaining academic integrity and fostering critical engagement.

The findings also have distinct implications for key stakeholders. For instructors, NF AI presents opportunities to scale formative feedback and support personalised learning but demands intentional design, ethical scaffolding, and pedagogical oversight. Educators must develop AI literacy for their own practice and to model responsible use for students. For researchers, the study highlights the need to extend theoretical models like AT to account for AI's dual roles and to investigate long-term learning outcomes, equity impacts, and human-AI dynamics across disciplines. For policymakers and institutional leaders, the results stress the importance of infrastructure readiness, vendor alignment, and robust governance frameworks. Challenges such as data privacy, feedback equity and clear AI integration processes show that policy must address not just technological capability but systemic and ethical interdependencies.

The future of AI in higher education depends on how well institutions balance technological efficiency with human judgment, ensuring learning remains rigorous, inclusive, and student-centred. AI should complement rather than replace educators, preserving academic mentorship and human interaction. By integrating AI effectively, institutions can harness its advantages while mitigating challenges, ensuring it enhances learning rather than disrupts it. This research contributes to both theoretical understanding and practical AI adoption, reinforcing the need for structured implementation strategies. Successful AI integration requires sustained investment in continuous staff learning and professional development, including adequate time, expertise, funding, and institutional support, to ensure AI technologies are applied ethically and meaningfully in higher education.

Limitations

This study provides valuable insights into the integration of AI teaching assistants in business education; however, it should be acknowledged that the research is limited to a single institution in New Zealand, which may restrict the generalisability of the findings to other educational contexts. Future research should explore the use of AI teaching assistants across multiple universities and diverse geographical regions to assess cross-cultural and institutional variations in AI adoption and effectiveness. Additionally, while this study focuses on the NF AI tool, comparing multiple AI teaching assistant platforms would provide a more comprehensive understanding of their relative strengths, limitations, and pedagogical impact.

Abbreviations
NF AI: Noodle Factory AI.

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Author's contributions
Gedera, D. and Griffiths, C. designed the study. Gedera, D., collected and analysed the data and drafted the manuscript with support and contributions from Griffiths, C. Both authors contributed to the review and revision of the final manuscript. All authors read and approved the final version.

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