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The Dialogic Dual-Instructor Model (DDIM): An Edu-informatics and STEAM-Oriented Approach to Effective University Teaching in Post-COVID-19 Higher Education

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Abstract

This study investigates which instructional formats most effectively promote student understanding and engagement in post-COVID-19 higher education. While the pandemic accelerated diversification in teaching modes including synchronous online classes, on-demand videos, and blended formats, limited empirical evidence exists comparing their effectiveness. Drawing on dialogic pedagogy, STEAM education principles, and the eduinformatics framework, we examine monologic single-instructor lectures, teaching assistant-supported classes, and dialogic co-teaching formats. We introduce the Dialogic Dual-Instructor Model (DDIM), a collaborative teaching approach implemented across statistics courses at Kobe Tokiwa University since 2017. DDIM involves two instructors engaging in structured dialogue during instruction, with one primarily presenting content while the other poses questions, requests clarifications, and offers alternative perspectives that mirror student thinking processes. This approach has been successfully adapted across face-to-face, audio-only, and on-demand video formats. Based on qualitative analyses of classroom implementations and instructor reflections, our analysis, synthesizing prior research on tutorial-style videos and dialogic practices in STEAM contexts with our collaborative statistics education practice, suggests that DDIM represents an effective instructional format particularly for conceptually demanding university courses, for fostering student engagement and understanding in contemporary university education.

Keywords: Dialogic Dual-Instructor Model (DDIM), Eduinformatics, post-COVID-19 education, STEAM education

1 Introduction

1.1 Society 5.0

The concept of Society 5.0, introduced by the Japanese government in 2016, represents a transformative vision for the future of human civilization ([1]). This framework outlines an evolutionary progression through distinct societal phases: Society 1.0 characterized by hunting and gathering communities, Society 2.0 defined by agricultural development, Society 3.0 marked by industrial advancement, Society 4.0 shaped by information technology, and finally Society 5.0, which envisions a super-smart society where cyberspace and physical space are highly integrated (Fig. 1). This new societal model aims to balance economic advancement with the resolution of

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social challenges by incorporating innovations such as the Internet of Things (IoT), artificial intelligence (AI), big data, and robotics into all facets of industry and social life.

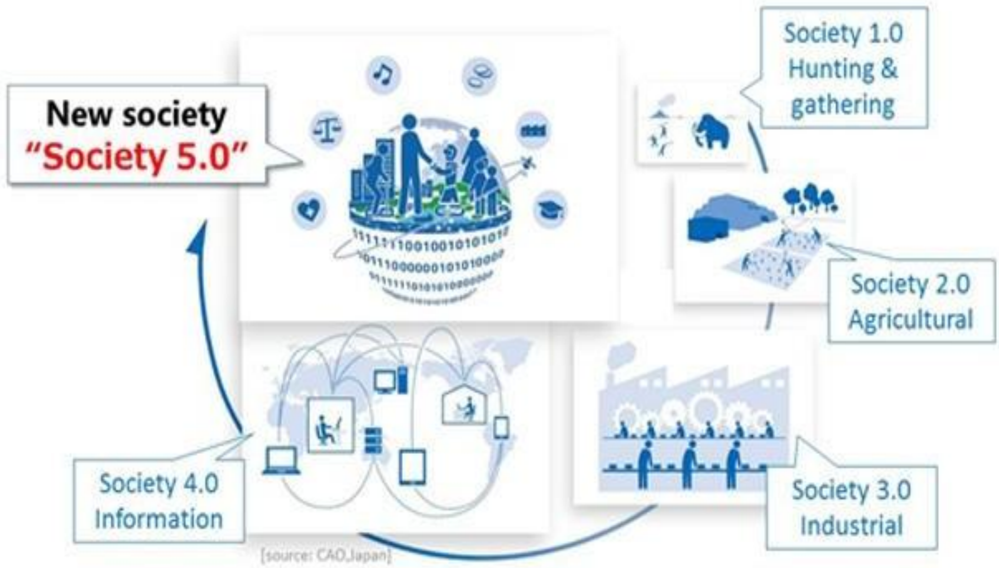

Figure 1: Society 5.0 ([1]).

At the heart of Society 5.0 lies a human-centered approach that distinguishes it from previous societal paradigms. While Society 4.0 focused primarily on connecting information systems and optimizing digital networks, Society 5.0 emphasizes the integration of technology to enhance quality of life and address pressing societal issues including aging populations, environmental sustainability, and healthcare accessibility. Globally, this paradigm is often referred to as Industry 5.0, particularly in European contexts, where similar principles of human-centricity, sustainability, and resilience guide industrial and societal transformation [2]. As illustrated in Figure 2, Industry 5.0 and Society 5.0 share complementary visions, with Industry 5.0 focusing on sustainable and resilient technologies while Society 5.0 emphasizes providing necessary goods and services to individuals at the appropriate level. This vision promotes a society where technological innovation serves human needs rather than simply pursuing efficiency or economic growth. The framework suggests that by merging virtual and physical realms, diverse societal challenges can be addressed while ensuring that individuals can lead comfortable and fulfilling lives.

The implications of Society 5.0 for higher education are profound and multifaceted. Traditional educational models, which primarily emphasized knowledge transmission and rote learning, are increasingly inadequate for preparing students to thrive in this emerging landscape. The Organization for Economic Co-operation and Development (OECD) has responded to these shifts by advocating for competency-based educational frameworks that distinguish between technical competencies and core competencies encompassing interpersonal, strategic, and delivery-related skills [3]. In the Society 5.0 era, education must transcend mere knowledge acquisition to cultivate abilities in knowledge application, creative problem-solving, and the generation of novel insights. This necessitates pedagogical approaches that foster critical thinking, interdisciplinary collaboration, and adaptive learning capabilities.

Furthermore, the transition to Society 5.0 demands educational institutions to reimagine their role as facilitators of lifelong learning and innovation hubs. Universities and colleges must evolve from being knowledge repositories to becoming dynamic environments where students actively engage in solving real-world problems through interdisciplinary collaboration. This paradigm shift aligns closely with the principles of Science, Technology, Engineering, Arts, and Mathematics (STEAM) education, which integrates arts and humanities with science and technology disciplines, thereby fostering the holistic skill development necessary for navigating complex societal challenges in the age of Society 5.0.

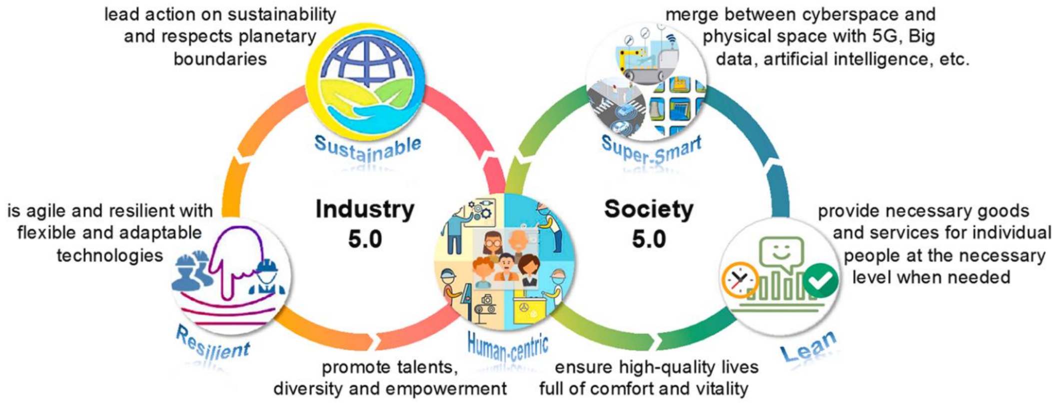

Figure 2: Vision of Industry 5.0 and Society 5.0 ([2]).

1.2 Eduinformatics

The emergence of Society 5.0 and Industry 5.0 necessitates innovative approaches to address evolving educational challenges in higher education. In response to this need, Eduinformatics has been proposed as a novel interdisciplinary field that bridges education and informatics [4], [5]. This emerging discipline aims to tackle contemporary educational problems by leveraging advanced methodologies from informatics, including data science, machine learning, artificial intelligence, and institutional research. As illustrated in Figure 3, Eduinformatics represents the intersection of two domains: education brings forth problems that need to be addressed, while informatics provides sophisticated problem-solving methods and analytical tools.

The conceptual framework of Eduinformatics draws inspiration from the success of bioinformatics, which revolutionized biological sciences by applying computational methods to analyze complex biological data. Similarly, Eduinformatics seeks to transform educational practices by introducing data-driven approaches to understand and optimize learning processes. This interdisciplinary nature positions Eduinformatics as a comprehensive management information system for education that enables practical applications across diverse educational contexts.

The application of Eduinformatics has become increasingly critical in the context of twenty-first century education, where evidence-based decision-making and personalized learning experiences are paramount. Traditional educational research often relied on qualitative observations and small-scale studies, limiting the generalizability and scalability of findings. Eduinformatics addresses these limitations by enabling large-scale data collection, sophisticated pattern recognition, and predictive modeling. Through learning analytics, educational institutions can identify at-risk students, optimize curriculum design, and evaluate the effectiveness of pedagogical interventions in real-time. Furthermore, Eduinformatics facilitates the development of adaptive learning systems that respond dynamically to individual student needs, thereby supporting the personalized education essential for Society 5.0.

In the realm of STEAM education and nursing education specifically, Eduinformatics offers powerful tools for understanding how students develop both technical competencies and the artistic sensibilities crucial for holistic patient care. By analyzing patterns in student learning trajectories, engagement metrics, and competency development, educators can refine instructional strategies to better cultivate the "art" of nursing alongside scientific knowledge. This data-informed approach aligns perfectly with the goals of the current research project, which seeks to establish minimum essentials for STEAM education in fundamental nursing education, particularly focusing on nurturing the artistic dimensions of nursing practice that Florence Nightingale emphasized as integral to the profession.

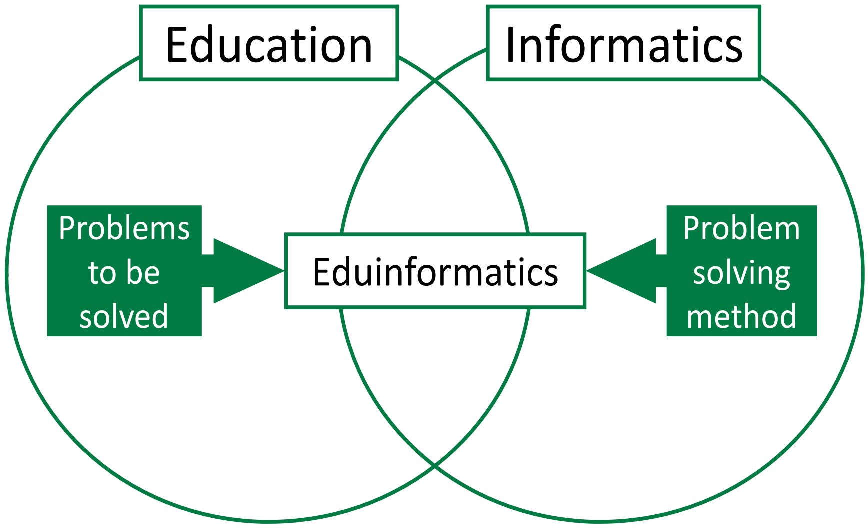

Figure 3: The concept of Eduinformatics from [4].

In this study, the Eduinformatics framework functions as an analytical lens for examining how different instructional formats influence student engagement and understanding. By integrating empirical classroom observations with theoretical perspectives, we apply Eduinformatics not only as a technological concept but as a methodological foundation for our qualitative analysis presented later in this paper (Qualitative Analysis and Discussion).

1.3 STEM and STEAM Education

The importance of Science, Technology, Engineering, and Mathematics (STEM) education has been widely recognized as fundamental for twenty-first century learning. In 2010, Bybee highlighted the significance of STEM education in the prestigious journal Science, discussing how STEM education addresses not only science and mathematics but also technology and engineering for citizens navigating the complexities of modern society [6]. STEM education plays a crucial role in promoting scientific literacy among younger generations and preparing them to tackle multifaceted challenges that require integrated knowledge across multiple disciplines. This educational approach has become increasingly vital as societies worldwide grapple with issues ranging from climate change to public health crises, all of which demand scientifically informed decision-making and innovative problem-solving capabilities.

Building upon the foundation of STEM education, the integration of Arts has given rise to STEAM education, where the "A" represents Arts in its broadest sense, encompassing creative thinking, design, humanities, and aesthetic sensibilities [7]. This expansion from STEM to

STEAM reflects a growing recognition that creativity, critical thinking, and holistic approaches are essential for addressing complex real-world problems. The inclusion of Arts is not merely an addition but a transformative element that enriches the learning experience by fostering innovation, enhancing communication skills, and developing emotional intelligence alongside technical competencies. STEAM education has gained considerable attention in recent years, with research demonstrating its effectiveness in early childhood education through higher education across diverse disciplinary contexts [8].

The relevance of STEAM education to nursing is particularly profound and aligns closely with the historical foundations of the profession. Florence Nightingale famously stated that "Nursing is a science and an art," establishing the dual nature of nursing practice that persists to this day. The "art" of nursing encompasses compassionate patient care, effective communication, ethical decision-making, and the ability to perceive subtle changes in patient conditions that may not be immediately apparent through scientific measurements alone. This artistic dimension requires sensitivity, intuition, and creativity—qualities that are cultivated through the Arts component of STEAM education. In fundamental nursing education, STEAM principles can help students develop both the technical competencies necessary for evidence-based practice and the humanistic sensibilities essential for patient-centered care.

The current research project, which aims to identify the minimum essentials of STEAM education that contribute to nurturing the art of nursing in fundamental nursing education, addresses a critical gap in contemporary nursing pedagogy. By integrating STEAM education principles into nursing curricula, educators can create synergistic effects that enhance both scientific knowledge and artistic practice. This approach prepares nursing students to thrive in the Society 5.0 era, where human-centered care supported by advanced technologies requires professionals who can seamlessly blend technical expertise with compassionate, creative, and culturally sensitive practice.

Furthermore, the process of generating novel insights and creative solutions in STEAM education closely aligns with the concept of abduction, a form of inference that enables hypothesis formation from observed patterns or contradictions [9]. Unlike deduction or induction, abduction allows learners to make creative leaps toward new explanations when confronted with surprising observations or contradictions between theory and practice. In nursing education, this abductive reasoning becomes particularly valuable when students encounter clinical situations that challenge established protocols or when they must integrate artistic elements of care with scientific knowledge. The ability to engage constructively with such contradictions and generate novel approaches represents a crucial competency for twenty-first century healthcare professionals. The cultivation of nursing's art through STEAM education thus represents not merely an educational innovation but a return to the holistic vision of nursing that Nightingale articulated over a century ago, now reimagined for the challenges and opportunities of the twenty-first century, enriched by contemporary understanding of creative reasoning and hypothesis formation.

2 Research Question and Method

The Covid-19 pandemic, which began in 2020, abruptly disrupted face-to-face teaching in higher education and forced universities around the world to shift to so-called emergency remote teaching [10]. Within a very short period of time, many institutions adopted synchronous online classes using videoconferencing tools such as Zoom, often without sufficient preparation on the part of either instructors or students [10]. This rapid transition exposed a wide range of challenges and possibilities related to online learning, including issues of access, digital literacy, interaction, assessment, and the design of learning support [10].

After this initial emergency phase, universities began to explore more stable and diverse online teaching formats [11]. In addition to synchronous online classes, many institutions started to incorporate on-demand lecture videos, learning management systems, and various forms of blended or HyFlex teaching that combine face-to-face, synchronous online, and asynchronous components [11]. As campus activities gradually resumed, these formats did not simply disappear; instead, they began to coexist with revived face-to-face classes, leading to a more complex landscape of instructional modes than before the pandemic [12].

This diversification of delivery modes has also stimulated changes in instructional design within individual courses. In addition to traditional lectures delivered by a single instructor, we now see courses that regularly involve teaching assistants (TAs) for question handling and exercise support, team-taught classes in which two or more instructors conduct dialogic teaching, and flipped classrooms that combine pre-recorded lecture videos with in-person discussion. Especially in the post-Covid-19 context, such variations in teaching formats appear to be increasing. However, it remains insufficiently understood which of these formats most effectively promote students' understanding and engagement. Against this backdrop, the present study focuses on the design of university classes and asks which instructional formats are educationally most beneficial for students.

Building on the transformations described above, the present study focuses on how different instructional formats that emerged or spread during and after the Covid-19 pandemic influence student learning. In contemporary university classrooms, instructors can choose among a range of options: traditional monologic lectures delivered by a single instructor, lectures in which a teaching assistant (TA) is regularly involved in facilitating questions and exercises, and dialogic or co-taught classes in which two or more instructors jointly conduct the session through conversation. These formats can be implemented in face-to-face settings, fully online environments, or combined with on-demand lecture videos in blended or flipped designs. Although each format is supported by plausible theoretical arguments, there is still limited empirical evidence directly comparing their impact on students' understanding and engagement.

Against this backdrop, the present study addresses the following research question:

RQ: In post–Covid-19 higher education, among various instructional formats such as single-instructor monologic lectures, lectures with teaching assistants, and dialogic co-taught classes, which formats most effectively promote students' understanding and engagement?

To explore this question, we conducted a qualitative analysis of teaching practices and instructor reflections at Kobe Tokiwa University, focusing on statistics education as a representative case of conceptually demanding university courses. This analysis, presented in the next section (Qualitative Analysis and Discussion), aims to identify how dialogic and monologic instructional formats influence student engagement and understanding in such contexts.

3 Qualitative Analysis and Discussion

This section presents a qualitative analysis of dialogic and monologic instructional formats based on our classroom implementations and instructor reflections, complemented by prior studies on tutorial-style videos and dialogic teaching. The aim is not to provide statistical test results but to synthesize empirical insights from related research and practice-based evidence from our Eduinformatics and STEAM-oriented teaching projects.

3.1 Related Work

Chi et al. examined why tutorial videos featuring a tutor working with a learner tend to support better learning than traditional lecture-style recordings delivered by a single instructor [13]. Using the ICAP framework, they analyzed not only the exchanges inside the tutorial videos but also the peer conversations of students who watched these videos in pairs. Their results showed that videos in which two roles jointly construct explanations naturally elicited more constructive and interactive behaviors from observers than one-way expository recordings, and that observers could learn as much as the learners who appeared in the videos themselves [13].

Building on this line of work, Qian, Hong, and Chi conducted two large-scale studies in online STEM courses (biology and mathematics) to compare tutoring-style videos with conventional lecturing videos in authentic course settings [14]. They found that students who watched tutor–learner videos achieved higher conceptual understanding than those who watched single-instructor lectures, regardless of whether they studied individually or collaboratively, as long as they engaged in generative activities such as explaining or summarizing [14]. From the perspective of the ICAP theory, the authors argued that observing a tutor guiding a learner tends to prompt viewers to anticipate answers, evaluate reasoning, and mentally participate in the exchange, whereas watching a single speaker leads more easily to passive reception.

In the Japanese context, Yin and Kubota analyzed the use of pre-recorded classes supported by a learning management system (LMS) at a private university [15]. Focusing on an on-demand course that combined short weekly lecture videos, reflective postings on a bulletin board, and frequent online quizzes, they examined how students used the LMS and how this related to their final performance. Questionnaire data from Kansai University indicated that many students held positive attitudes toward on-demand classes and wished such formats to continue even after the Covid-19 period, regarding the LMS as a convenient hub for accessing materials and communicating about coursework [15]. This study illustrates how video-based teaching can be embedded in an environment that supports autonomy, reflection, and interaction, rather than functioning as purely one-way content delivery.

Ding et al. focused on the role of learner mistakes in tutor–learner videos used in an undergraduate biology course [16]. They compared versions of the videos in which the learner role made noticeable errors that were then corrected by the tutor with versions that did not include such episodes, and examined how students with different levels of prior knowledge benefited from these materials. Their results showed that students with higher prior performance learned more from videos containing error episodes, presumably because identifying and resolving mistakes stimulated deeper processing, whereas lower-performing students did not experience the same advantage [16]. This suggests that including carefully designed error scenes in conversation-based instructional videos can create productive struggle for some learners, but the effectiveness depends on learners' initial knowledge and the surrounding scaffolding.

3.2 Defining Monologic and Dialogic Instruction in Art- and STEAM-Oriented Education

In this paper, monologic instruction refers to teaching formats in which a single instructor, or a single institutional voice, presents knowledge in a predominantly one-way, expository manner. Even when the instructor anticipates learners' questions or uses rhetorical prompts, the overall structure is governed by a unified authoritative voice, and meanings are largely presented as already formed rather than negotiated. This corresponds to what Bakhtin and subsequent scholars of dialogic pedagogy describe as non-dialogic, transmission-oriented discourse, in which students have few opportunities to publicly shape the development of ideas in real time [17], [18] . In the context of lecture videos or university classes, monologic formats therefore center on explanation and demonstration by one speaker, with learner contributions (questions, reflections, peer discussion) occurring outside the main teaching text rather than being structurally embedded within it.

By contrast, dialogic instruction in this study denotes formats in which two or more distinct voices are structurally present in the teaching text and where understanding is developed through their exchange—through questioning, probing, challenging, clarifying, or co-constructing explanations. Drawing on Bakhtinian and Freirean traditions, dialogic pedagogy treats teachers and learners as co-participants in inquiry, emphasizing the joint exploration of problems rather than the delivery of finalized content [17], [18], [19]. In art museum and gallery education, dialogic approaches have been investigated as ways of positioning museums as "spaces for citizenship," where educators and visitors engage in open-ended discussion around artworks instead of receiving fixed interpretations [19].

Within the Art component of STEAM, dialogic processes have long been treated as central to learning and making. Visual Thinking Strategies (VTS) is a prominent example: facilitators pose open questions such as "What is going on in this picture?" and "What do you see that makes you say that?", paraphrasing and linking participants' responses to foster observation, reasoning, and language development through group discussion [20], [21].

Studio-based art education similarly institutionalizes dialogue through critique sessions, in which students, peers, and instructors collaboratively interpret works-in-progress, articulate intentions, and negotiate evaluative criteria; research has documented both the centrality of such critiques and ongoing debates about how to structure them for more equitable, growth-oriented feedback [21].

In socially engaged art, Kester's notion of "dialogical aesthetics" conceptualizes artistic practice itself as rooted in sustained conversations with communities, where artistic meaning emerges in and through dialogue rather than residing solely in discrete objects [22], [23].

A/r/tography extends this orientation by framing arts-based educational research as a "living inquiry" in which the roles of artist, researcher, and teacher (a/r/t) are interwoven through ongoing relational and dialogic processes [24], [25].

Building on these traditions, the present study uses monologic and dialogic to distinguish, in a focused way, between single-instructor formats and multi-voice formats in university teaching, including cases where two instructors publicly engage in questioning, explanation, and clarification that students can observe as a model of collaborative thinking.

3.3 Our STEAM/Eduinformatics Practice and Dialogic Teaching at Kobe Tokiwa University

3.3.1 Background and Course Design

Our previous work at the intersection of STEAM education and Eduinformatics has focused on how knowledge is generated, connected, and visualized rather than merely transmitted. One line of research proposed knowledge network model education for STEM/STEAM by constructing large-scale keyword co-occurrence networks from picture books, showing how simple learner-generated keywords can expand into complex knowledge graphs in the context of ICT, Industry 5.0, and Society 5.0 [26].

A second line of work designed and evaluated an Active Learning STEAM/Data Science program in first-year "Manaburu" courses at Kobe Tokiwa University, where sports- and exercise-based facilitation, team-based tasks, and data-driven Eduinformatics analysis of SPI pre/post scores demonstrated that facilitator-centered, interaction-rich designs can significantly enhance intrinsic motivation and learning outcomes [27].

A third contribution articulated a long-term vision of higher education by linking Eduinformatics with the Japanese concept of Shu–Ha–Ri, arguing that universities must move from rigid, discipline-bound "Shu" models toward a "Ri" stage characterized by creativity, STEAM, and particularly the "A" of Art as a dialogic and culturally embedded mode of knowledge creation [28]. Across these studies, the role of the instructor has been consistently reframed from that of a sole knowledge provider to that of a facilitator of interaction, reflection, and co-construction—an orientation that directly informs the present focus on instructional formats in statistics education.

3.3.2 Implementation of the Dialogic Dual-Instructor Model (DDIM)

At Kobe Tokiwa University, the first author and the last author have collaboratively implemented statistics education in two major strands—descriptive statistics and inferential statistics—across multiple faculties and departments, intentionally adopting a shared-teaching format. Descriptive statistics is offered as Basic Statistics, a foundational course under the new curriculum introduced in 2017. From 2017 to 2019, Basic Statistics was taught face-to-face as a basic subject open to students across the university. When Covid-19 restricted classroom teaching, the course shifted to audio-only distribution in the 2020 and 2021 academic years, supported by an original textbook with line and equation numbers that allowed precise reference between explanations and materials even without video. Since 2022, Basic Statistics has been offered as an on-demand YouTube course. In all these modes—face-to-face, audio, and video—the class has been managed through the LMS manaba, and the first author and the last author have shared responsibility in the classroom: one leading the main exposition, the other interjecting with questions, checks, and alternative explanations that anticipate students' difficulties and make the process of understanding explicitly observable.

Inferential statistics has been deployed under different course titles in several departments but is coordinated as a common content strand. In the Faculty of Health Sciences, Department of Medical Technology, the course is offered as Medical Statistics, first introduced in 2017 under the former curriculum and re-opened this year in the fourth year after a curriculum revision. In the Faculty of Health Sciences, Department of Radiological Technology, inferential statistics is offered as Applied Mathematics, delivered via manaba since the 2022 academic year. In the Faculty of Health Sciences, Department of Oral Health Sciences, a new course titled Mathematics and Data Science (Inferential Statistics) was introduced in the current academic year, filling a curricular gap where no equivalent subject had previously existed. In these three courses—Medical Statistics, Applied Mathematics, and Mathematics and Data Science (Inferential Statistics)—the first author and the last author jointly conduct classes, again using complementary roles in explanations, questioning, and example selection. By contrast, Health Statistics in the Faculty of Nursing, Department of Nursing is taught by a single instructor and is therefore outside the scope of the present discussion, which focuses on two-instructor formats.

Across Basic Statistics and the three inferential statistics courses, a shared design principle is that the interaction between two instructors is made visible as part of the teaching text itself. One instructor often takes a role closer to a "specialist," responsible for introducing theoretical concepts and formal procedures, while the other temporarily adopts a stance closer to a "learner" or "advanced peer," voicing potential misunderstandings, requesting clarification, or offering alternative perspectives that mirror likely student questions. This structural arrangement embodies the dialogic orientation discussed in our theoretical and STEAM/Eduinformatics work: rather than presenting knowledge as a finished product from a single authoritative voice, the courses model a process in which concepts are probed, negotiated, and refined through the interplay of distinct viewpoints. In face-to-face settings, this interplay appears as live conversation; in audio and on-demand video formats, the same structure is preserved in recorded explanations, enabling learners to overhear a process of joint reasoning rather than only a solitary exposition.

3.3.3 Pedagogical Implications from a STEAM and Eduinformatics Perspective

Returning to our research question—In post–Covid-19 higher education, among various instructional formats such as single-instructor monologic lectures, lectures with teaching assistants, and dialogic co-taught classes, which formats most effectively promote students' understanding and engagement?—our accumulated practice suggests that two-instructor, dialogic teaching designs offer a particularly promising answer. They align with our earlier STEAM/Eduinformatics findings that active, facilitator-centered and interaction-rich environments foster motivation and deep learning [18]–[20]; they lower psychological barriers by allowing one instructor to temporarily represent the learner's position; and they provide a robust design pattern that can carry across face-to-face, audio, and on-demand video modalities without depending solely on real-time interaction. While systematic, large-scale outcome analyses of these statistics courses remain a task for future Eduinformatics research, the synthesis of our prior studies and our multi-department teaching practice at Kobe Tokiwa University supports the conclusion that dialogic co-teaching is a strong candidate for an effective instructional format   especially in courses that require conceptual understanding such as university statistics education and, more broadly, a concrete, practice-based response to the research question posed in this study.

4 Conclusion

This paper addressed the following Research RQ, which we restate here: In post–Covid-19 higher education, among various instructional formats such as single-instructor monologic lectures, lectures with teaching assistants, and dialogic co-taught classes, which formats most effectively promote students' understanding and engagement?

Synthesizing prior findings on two-person instructional videos, on-demand/LMS-supported courses, and dialogic practices in Art/STEAM with our own co-taught statistics courses at Kobe Tokiwa University, we conclude that two-instructor, dialogic co-teaching is the most promising instructional format among those considered for fostering student understanding and engagement, particularly in courses that require analytical and conceptual understanding, in the post–Covid-19 context.

Acknowledgement

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