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Interdisciplinary Collaboration in Interactive Design Projects: A Review

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Abstract

Interdisciplinary collaboration is essential in modern interactive design projects, which often encompass digital, physical, and experiential components requiring diverse expertise. This study explores the nature and impact of interdisciplinary collaboration in such projects through a systematic literature review, focusing on key concepts, challenges, and best practices. The findings from 9 included studies highlighted the multifaceted benefits of integrating disciplines like design, engineering, computer science, and psychology, which collectively enhance innovation, project outcomes, and professional development.

This collaboration produces innovation through the development of new ideas, thoughts, as well as innovative ideas which can be developed into products that single isolated fields might never develop, it also fosters professional growth of team members as they learn new techniques and theories from one another resulting to a wider and more flexible workforce. Both in education and in a more generalized context, interdisciplinary projects promote a high level of student engagement - encouraging not just critical-thinking skills but the practical application of skills to solve real-world problems.

Among the key success factors outlined in the review are increased communication, well established roles, technology integration, and a shared trust and respect. Key to supporting these collaborations are digital and interactive technologies, such as virtual reality and modular programming, each introducing new challenges like training and compatibility.

Interdisciplinary projects also have major social and cultural benefits. They strengthen committed and social relationships among those who engaged in shared activities, promoting a culture of social innovation.

In summary, the review suggests that that interdisciplinary work is not just more effective, but mandatory for addressing the challenges of interactive design projects. Longitudinal studies of educational impacts, continued integration of emerging technologies, and the establishment of frameworks to support interdisciplinary collaboration will be key topics for future research. This understanding would assist practitioners and educators in making interdisciplinary efforts more effective, contribute to better project outcomes and richer social and cultural offerings.

Introduction

Modern design problems are complicated and need an interdisciplinary design approach, reflecting the present-day complex technological and social environment (Reeves et al., 2016). This includes interactive design projects, an area that often features digital, physical, and experiential components all interworking as one (Szalapaj, 2014). The convergence of these discourses can significantly inform projects, bridging gaps between domains such as design, engineering, computer science, psychology, and many others. Interdisciplinary collaboration, at its core, is about taking the best of various fields and combining those skills to accelerate innovation and solve more complex problems than can likely be tackled by any single field alone (Klaassen, 2018). For multiple reasons, the interdisciplinary association within interactive design projects is essential. First, they tend to be highly multi-disciplinary; that is, they typically address complex issues that defy an easy, tidy embrace solely by one nominee area of expertise and knowledge (Cascini et al., 2017). For instance, creating an educational tool may need inputs from educators, designers, software developers, and psychologists (Tobi and Kampen, 2018). The fact that every discipline brings in their unique insights and expertise results in a much more holistic and impactful solution (Blandford et al., 2018) (Figure 1).

Furthermore, a multidisciplinary approach is key to innovation (Aftab et al., 2015). Different line professionals always mean different line perspectives and solutions in problem-solving (Prestes Joly et al., 2019). Such voting diversity can more often result in the creative breakthrough that cannot be discovered in a hardware group (Razmak and Bélanger, 2016). A great example is when a designer focuses on user experience to match an engineer's technical prowess; products that work not only well but work well will be more usable and engaging applications (Chasanidou et al., 2014).

The second key value of interdisciplinary work is the promise of expanding latter stages of professional development and learning as such (Havnes and Smeby, 2014). Collaborating with other disciplines allows them to learn new ideas from one another as well as the methods to help students (at all levels) outgrow previous distinctions (Carr et al., 2018). This cross-fertilization of expertise can produce a more multi-dimensional workforce with the demonstrated competency required to handle the sophisticated needs of contemporary interactive designs (Tytler et al., 2019). Interactive design is often categorized with human behavior or societal movements (Moirano et al., 2020). With the help of social science findings, such groups can produce a solution that is much more compassionate and befitting to the targeted users (Gao et al., 2020). Such as using behavioral insights when designing a health app to make it more effective in prompting positive behavioral change (Heitzmann et al., 2021).

This systematic literature review intends to explore and uncover the nature of interdisciplinary collaboration in interactive design projects. Drawing on a systematic review of the literature and individual cases, this review aims to identify the key concepts, problems, and best practices expected to facilitate further interdisciplinary efforts. This review covers a wide variety of interactive design projects, such as digital tools, VR environments, educational technologies, urban planning projects, and co-creative art installations..

The aim of this review is to provide an overview of the use of interdisciplinarity in interactive design projects and discuss its influence on the developed prototypes. This includes considering the processes used in enabling collaboration, how each discipline may work or contribute, and the tools used to make such collaboration possible. The review thereby seeks to underline key success and risk areas regarding interdisciplinary cooperation within these environments.

This review, therefore, covers one of the gaps by focusing on the pragmatic implications of interdisciplinary collaboration. This entails recognizing how to best structure and manage collaboration - and, in case things are less than ideal, how to conquer some common challenges.

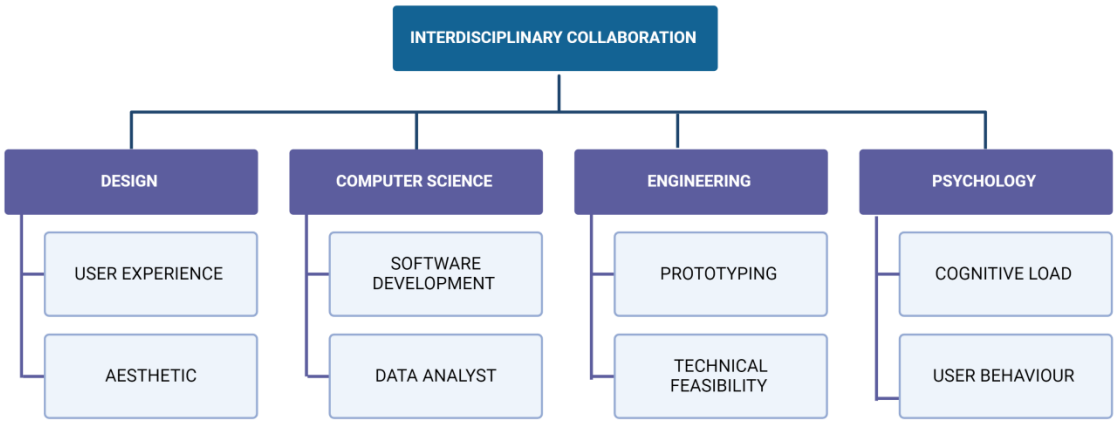

Figure 1 Interdisciplinary Collaboration in Project Development

This figure illustrates the collaborative efforts across four disciplines—Design, Computer Science, Engineering, and Psychology—within a project development framework. Each discipline contributes distinct expertise to the overall project:

Methodology

Literature Search:

A systematic literature search was conducted adhering to the PRISMA guidelines (Page et al., 2021) to ensure the comprehensive research on the desired topic by using several electronic databases, including IEEE Xplore, ACM Digital Library, ScienceDirect, and Google Scholar. Different keywords that were used in the search process included "interdisciplinary collaboration,""interactive design,""digital collaboration,""virtual reality,""design education," and "construction projects."

Inclusion and Exclusion Criteria:

The inclusion criteria were defined to select studies that:

1. Focus on interdisciplinary collaboration in the context of interactive design projects.
2. Are published in peer-reviewed journals.
3. Provide empirical data, case studies, or comprehensive reviews relevant to the research questions.

4. Are written in English to ensure accessibility and comprehensibility.

Conversely, the exclusion criteria were established to filter out studies that:

1. Do not explicitly address interdisciplinary collaboration or interactive design.
2. Are opinion pieces, editorials, or theoretical papers without empirical evidence.
3. Have insufficient methodological rigor or lack transparency in their research design.

Screening and Assessment:

The initial search yielded several hundred studies. These were first screened by title and abstract to eliminate irrelevant papers and duplicates using Rayan. The remaining studies were then assessed in full-text form to determine their eligibility based on the inclusion and exclusion criteria. Each study's relevance to the research questions was evaluated, and those that met the criteria were included in the final review.

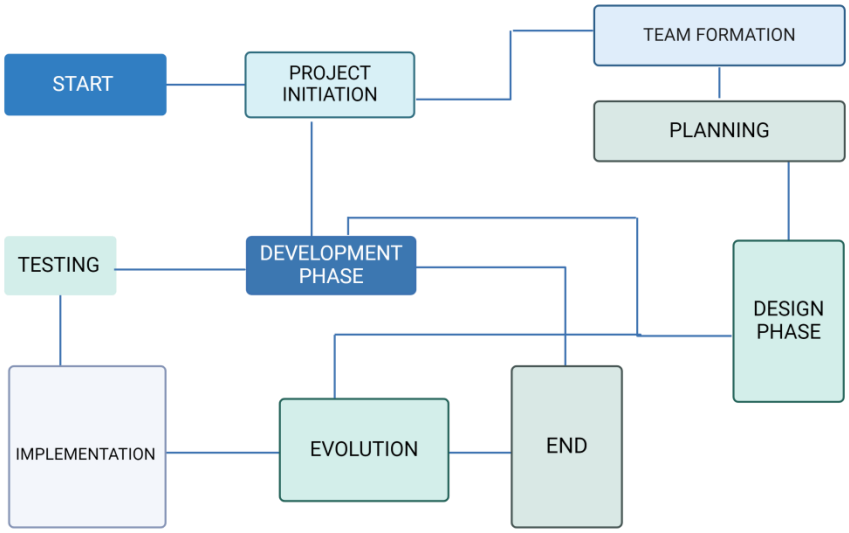

Figure 2 Flowchart Depicting the Phases and Activities in a Software Development Life Cycle (SDLC).

Start: Marks the beginning of the project. Project Initiation: The initial phase where the project scope, objectives, and feasibility are defined. Team Formation: Assembling the project team and defining roles

Planning: Developing a detailed project plan that outlines the steps, resources, and timelines. Design Phase: Creating the architecture and design of the software based on requirements. Development Phase: The actual coding and development of the software takes place in this phase. Testing: Verifying and validating the software to ensure it meets the requirements. Implementation: Deploying the software in the live environment. Evolution: Post-implementation phase where the software undergoes updates, enhancements, and maintenance. End: The conclusion of the project after meeting its objectives or the decision to terminate it.

Results:

The systematic literature search was performed across four major databases: IEEE Xplore, ACM Digital Library, ScienceDirect, and Google Scholar. The search used keywords such as "interdisciplinary collaboration,""interactive design,""digital collaboration,""virtual reality,""design education," and "construction projects," leading to a total of 723 records. After eliminating 112 duplicates, 611 unique studies remained for further evaluation. These were screened based on predefined inclusion criteria, including relevance to interdisciplinary collaboration in interactive design projects, publication in peer-reviewed journals, and the presence of empirical data, case studies, or comprehensive reviews. Studies not explicitly addressing interdisciplinary collaboration or interactive design, or lacking empirical evidence, were excluded. This resulted in the exclusion of 539 studies, leaving 72 full-text articles for detailed assessment. Following a thorough review, an additional 63 studies were excluded based on the final eligibility criteria, resulting in 9 studies being included in the final analysis. The Interdisciplinary collaboration flow chart is given in Figure 2, the detailed PRISMA flow chart of included studies is given in Figure 3. The detailed characteristics summary of Included studies is given in Table 1.

Table 1 Summary Table of Study Characteristics.

Study Title	Authors	Year	Keywords	Methods	Focus	Results
Evaluation and Development of Digital Collaboration Techniques for Interdisciplinary Collaboration	(Pokojski, 2020)	2020	Digital Collaboration, Matrix Network, Mixed Reality, Remote Maintenance	Evaluation, Development, Case Studies	Impact of Digital Collaboration Techniques on Interdisciplinary Collaboration	Developed a mobile collaboration environment integrating various digital tools to support interdisciplinary cooperation
The role of space in interdisciplinary collaboration in design education	(Kaygan and Aydınoğlu, 2018)	2018	Design education, Engineering education, Space, Collaboration, Interdisciplinarity, Design factory	Interviews, Participant Observation	Effect of Space on Interdisciplinary Collaboration among Tutors	Space significantly influences participation, commonality of expectations, and interaction among interdisciplinary teams

Teaching Collaborative and Interdisciplinary Service-Based Urban Design and Planning Studios	(Neuman, 2016)	2016	Urban Design, Interdisciplinary, Studio Teaching, Service-Based Learning	Studio Teaching, Case Studies	Collaborative and Interdisciplinary Urban Design Education	Found integrated service-based learning projects beneficial to students and communities
Interactive technologies facilitating collaboration between projetists and non-projetists: A laboratory design experience	(Costa et al., 2019)	2019	Interactive Technologies, Collaboration, Design, Interdisciplinary, Accessibility	Collaborative Workshop, Synchronous Environment	Impact of interactive technologies on interdisciplinary collaboration	Interactive technologies facilitate communication and collaboration in design processes, providing equal participation opportunities

Fostering Critical Collaborative Thinking through Digital Platform: An Empirical Study on Interdisciplinary Design Project	(Indraprastha, 2023)	2023	Collaborative Thinking, Interdisciplinary Design, Digital Platform, Project-Based Learning, AEC Industry	Project-Based Course, Surveys, Collaborative Workshops	Digital Platform's Role in Collaborative Thinking and Interdisciplinary Design	Digital platforms enhance collaborative engagement and critical thinking, but face challenges like communication and scheduling
A Review of Collaborative Virtual Reality Systems for the Architecture, Engineering, and Construction Industry	(Ververidis et al., 2022)	2022	AEC, VR, BIM, Collaboration, Interdisciplinary, Virtual Reality	Literature Review, Comparative Analysis	Collaborative VR Systems in AEC Industry	VR systems differ in features; proposed blueprint for ideal system with enhanced collaboration and communication
The Challenges of Designing the	(Maric, 2019)	2019	Interaction Design, Collaborative Art,	Case Study, Interviews, Surveys	Interaction Design in Collaborativ	Identified challenges and benefits of

Interaction Design of a Collaborative Art Project			Interdisciplinary Collaboration, User-Centered Design, Social Innovation		e Art Projects	interdisciplinary collaboration; emphasized the importance of user-centered design
Interdisciplinary Collaborative Learning with Modular Programming and Information Visualization of Urban Smart Spaces	(Wang and Wu, 2022)	2022	Interdisciplinary Learning, Modular Programming, Information Visualization, Collaborative Learning, Smart City	Interdisciplinary Course, Modular Programming, Information Visualization	Collaborative Learning in Smart City Design	Modular programming and information visualization improve collaborative learning; highlighted challenges in communication and project management

Exploring Interdisciplinary Collaboration in the Detailed Design Phase of Construction Projects	(Salam et al., 2019)	2019	Interdisciplinary Collaboration, Construction Projects, Detailed Design Phase, Collaboration Framework	Practice-Based Longitudinal Study, Interviews, Observations	Interdisciplinary Collaboration in Construction Design Phase	Identified key factors enhancing collaboration; proposed a comprehensive collaboration framework

Thematic Analysis of Interdisciplinary Collaboration

Thematic analysis reveals commonly occurring themes and findings that are generalizable across different context and application of ID collaboration in interactive design projects. The themes were grouped into main areas that each showed different aspects of interdisciplinary collaboration. Some themes that seem to come up repeatedly in these studies, which are foundational for successful interdisciplinary projects in interactive design. These themes attest to the complexity of collaboration as well as to the multiplicity of factors that feed into successful collaborative initiatives.

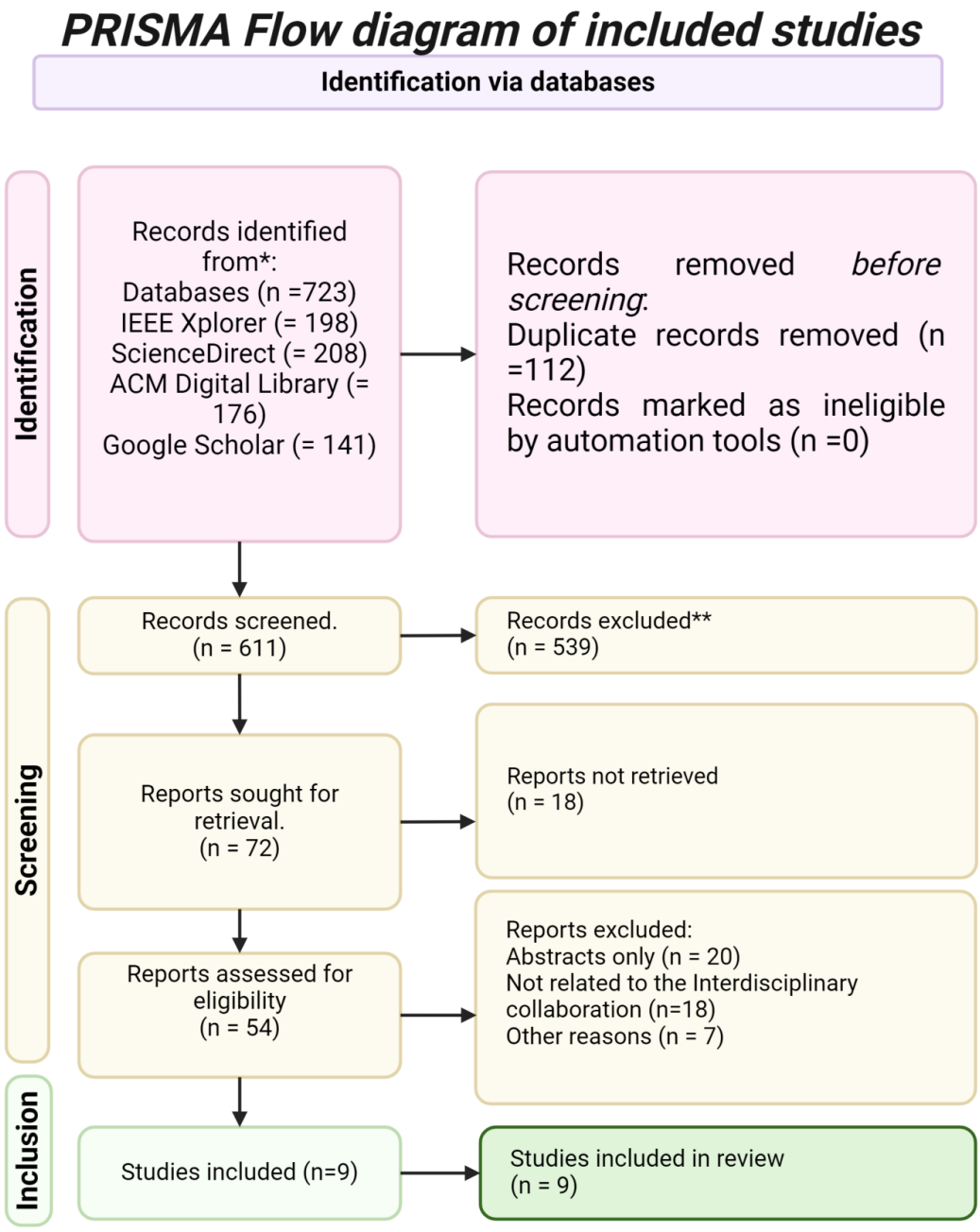

Figure 3 PRISMA Flow Diagram for the Inclusion of Studies in the Systematic Review.

Identification Phase: Records Identified: A total of 723 records were identified from various databases including IEEE Xplorer (n = 198), ScienceDirect (n = 208), ACM Digital Library (n = 176), and Google Scholar (n = 141). Records Removed Before Screening: 112 duplicate records were removed before the screening process, while no records were marked as

ineligible by automation tools. Screening Phase: Records Screened: 611 records were screened for relevance to the study criteria. Records Excluded: 539 records were excluded during the screening process. Reports Sought for Retrieval: Out of the screened records, 72 reports were sought for retrieval. Reports Not Retrieved: 18 reports could not be retrieved for further evaluation. Reports Assessed for Eligibility: 54 reports were assessed for their eligibility based on the inclusion criteria. Reports Excluded: Among the reports assessed, 20 were excluded for being abstracts only, 18 for not being related to interdisciplinary collaboration, and 7 for other reasons. Inclusion Phase: Studies Included in Review: After the thorough screening and eligibility assessment, 9 studies were included in the final systematic review.

Digital and Interactive Technologies

Many studies focus on the increased use of digital technologies within partnerships. Pokojski (Pokojski, 2020) addressed the evaluation and advancement of digital cooperation techniques, and examined the way in which these technical approaches are beneficial for interdisciplinary interaction. This presents the need for mobile collaboration environments that integrate with systems such as CAD, VR, and AR to enhance remote maintenance and research collaboration.

Digital technology offers numerous advantages for group applications and remote collaboration. They provide real-time communication, information sharing, and collective problem-solving. Whether through video conferencing, chat programs, or shared digital workspaces, team members from various disciplines can collaborate across distances and time zones. This level of access is crucial for effective interdisciplinary collaboration (Pokojski, 2020).

Costa et al. (Costa et al., 2019) studied the impact of interactive technologies on collaboration in a lab design experience. Their findings indicate that advanced interactive technologies, such as high-resolution PowerWalls and interactive tables, greatly enhance communication and collaboration among team members. These technologies enable participants to interact with data in real time, facilitating the suggestion and evaluation of design changes and upgrades.

Interactive technologies democratize the decision-making process, particularly in cross-disciplinary research where participants may have varying levels of technical expertise. By

breaking down complex data and design elements, interactive learning technologies create more universal and effective collaborative spaces (Figure 4).

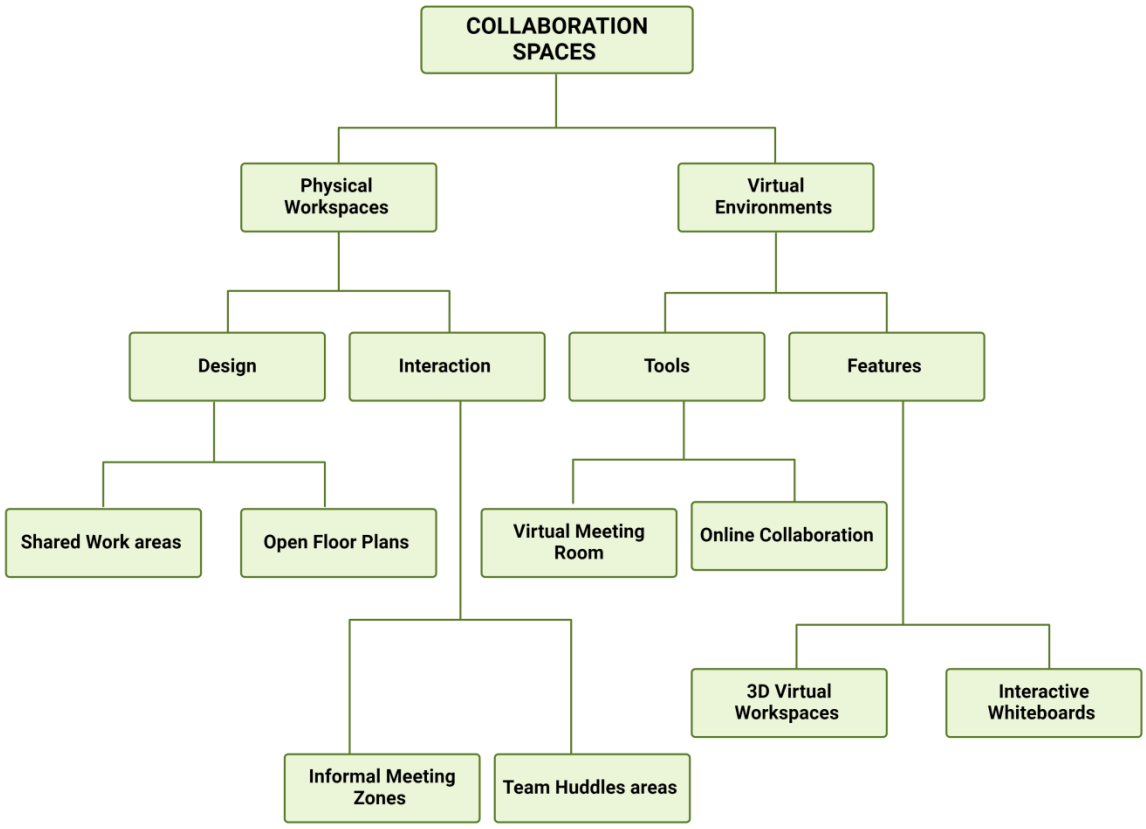

Figure 4 Hierarchical Diagram of Collaboration Spaces in Physical and Virtual Environments.

Collaboration Spaces: The overarching category, representing the different environments where collaborative activities can take place. Physical Workspaces: The branch of collaboration spaces that occur in the real world, involving tangible environments. Design: Shared Work Areas: Physical spaces designed for collaborative work among team members. Open Floor Plans: Layouts that promote interaction by removing physical barriers. Interaction: Virtual Meeting Room: Designated spaces for meetings within physical environments. Informal Meeting Zones: Areas intended for casual, spontaneous interactions. Team Huddles Areas: Specific zones for quick, focused team discussions. Virtual

Environments: The branch representing digital or online collaboration spaces. Tools: Online Collaboration: Platforms and tools that facilitate team collaboration remotely. 3D Virtual Workspaces: Digital environments that mimic physical spaces in three dimensions to enhance interaction. Features: Interactive Whiteboards: Digital tools that allow for real-time brainstorming and planning. Virtual Meeting Room: Digital spaces where virtual meetings take place, parallel to their physical counterparts in physical workspaces.

Role of Physical and Virtual Spaces

Kaygan and Aydınoğlu (Kaygan and Aydınoğlu, 2018) conducted a qualitative study examining how the physical environment supports interdisciplinary collaboration in design education. Their research highlights how the design of spaces influences participation, shared expectations, and interactions among interdisciplinary teams. Through the experiences of the METU Interdisciplinary Design Studio (IDS), the study underscores the challenges and successes encountered with local collaborative spaces.

Many physical collaboration spaces feature open floor plans, shared work areas, and informal meeting zones. These configurations encourage spontaneous idea exchange, which is crucial for effective collaboration. However, the study found that the absence of a dedicated, common space for IDS activities hindered successful interdisciplinary collaboration. On the other hand, well-designed collaborative spaces foster creativity and holistic solutions, enhancing the overall collaborative experience (Kaygan and Aydınoğlu, 2018).

Ververidis et al. (Ververidis et al., 2022) explored the use of collaborative VR systems in the architecture, engineering, and construction (AEC) industry. Their research demonstrates that VR can support interdisciplinary collaboration by enabling team members to work together in virtual environments using 3D models and simulations. Integrating VR with BIM improves the visualization and communication of design intent.

VR systems allow stakeholders from diverse backgrounds to virtually explore projects, identify design alternatives, and make unbiased decisions. This technology bridges the gap between abstract design principles and practical implementation, fostering a deeper understanding of design among teams. The research provides a blueprint for an ideal VR setup with advanced

functionalities to enhance coordination and communication in the AEC industry (Ververidis et al., 2022).

Pedagogical Approaches and Education

Neuman (Neuman, 2016) conducted the study on the integration of collaborative and interdisciplinary service-based learning in urban design and planning education. His research illuminates how studio teaching within an inclusive environment prepares students to engage in real world problem-solving collaborations. He also concluded that the training in new career paths among community health workers is beneficial, but only as a part of an interdisciplinary project engaging students, faculty and community clients, which reflects the learning opportunities and experiences associated with interprofessional education.

Service based learning projects get students out client facing, giving them some real world design experiences to see how complex projects can get. Much of this work is quite interdisciplinary in nature and students are often required to work collaboratively on them, which can lead to a more well-rounded view of how urban design and urban planning come into play. This type of integration of studio teaching according to Neuman had clear benefits for student learning, cross-cutting collaboration between disciplines, as well as directly serving the community need through professional application (Neuman, 2016).

Indraprastha (Indraprastha, 2023) discusses how well-structured project-based courses can facilitate collaborative thinking and development from critical perspectives by students coming from diverse disciplinary backgrounds. In his study, he presented a case study of students working collaboratively on cross-disciplinary design projects using digital platforms, conducted in Bandung Institute of Technology. He concluded that Project-based learning supports more student engagement more collaboratively and critically than more conventional approaches, but with issues including difficulties in communicating, timing challenges.

Project-based courses involve students working together on complex real-world problems, applying their disciplinary knowledge to develop practical solutions. This is because these courses help to develop teamwork, communication, and other problem-based solving skills essential for interdisciplinary collaboration. The paper emphasizes the influence of digital platforms for creating a collaborative learning environment (Indraprastha, 2023).

Design and Art Projects

Maric, (Maric, 2019) discussed the design of the interaction design (ID) of a collaborative digital art project. The study, which stems from the "Meet the Ministry" project, involves young people, one dance company, and an academic institution. The study has revealed the nuances and the unexpected challenges of interdisciplinary art project collaborations suggesting that the user-centered approach should be embedded in the context of care, organizing and planning, and social innovation development.

Collaborative art projects very typically embrace diversity where a project attracts people with a wide range of skills and backgrounds. In his research, Maric (Maric, 2019) outlines keys challenges, such as time management, language barriers and the digital integration of traditional artsophysical arts form. While these challenges are no easy feat, the project did succeed in creating greater youth engagement and learning, showing the possibilities of interdisciplinary works within the art & design field.

Through a collaborative learning case of urban smart space design, research by Wang & Wu (Wang and Wu, 2022) explored the construction of separate codes and information visualization. The study was conducted among students from different disciplines in collaboration while working on smart city design projects at National Taipei University of Technology. The study shows that long tasks are better modularized, resulting in students with specialisms of different programming skills to work together.

In IT, information visualization is paramount in helping team members better understand one another as well as in aiding better communication. It means that while forming arguments, they can use powerful visual data which will help other team members correlate their design decisions and, in the process, facilitate a much more effective collaboration. The research supports the need to expand on module-based programming and information visualization in the interdisciplinary curriculum to foster beneficial co-learning results (Wang and Wu, 2022) (Figure 5).

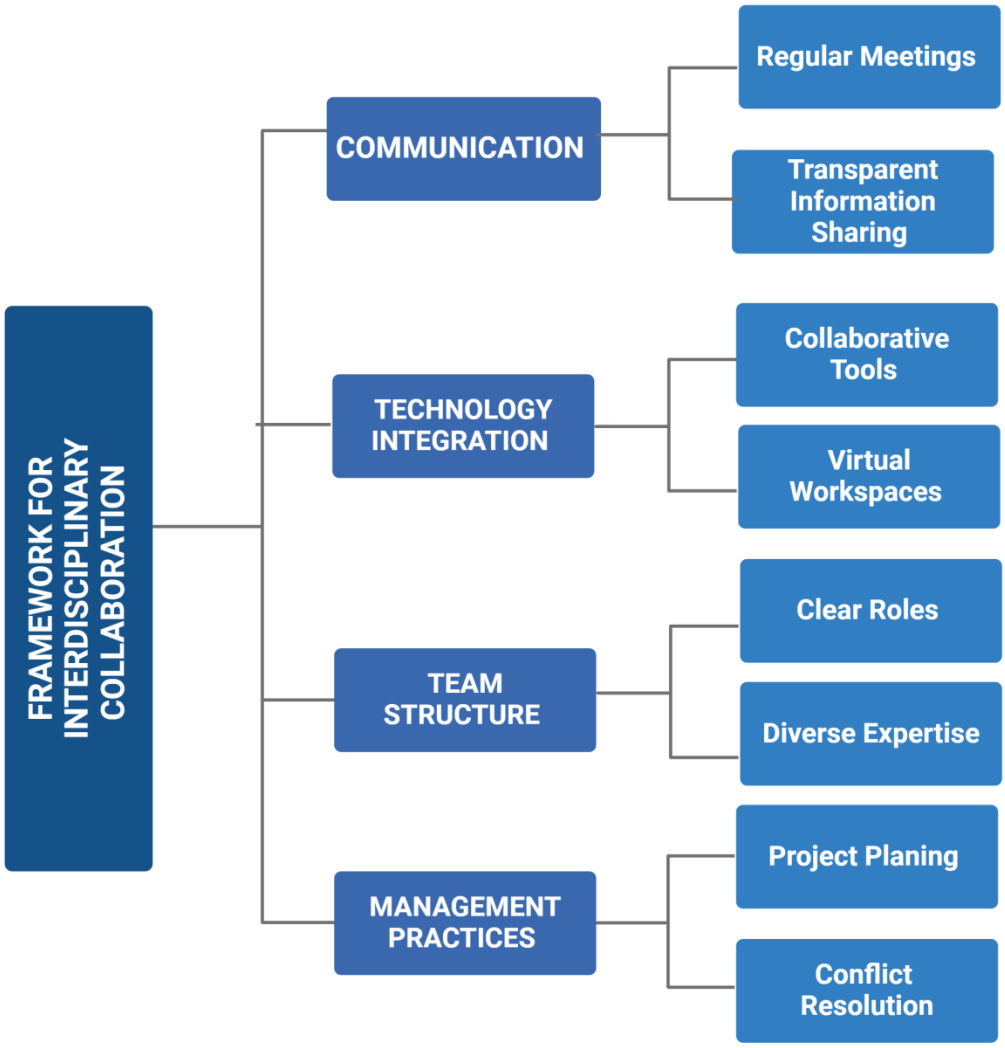

Figure 5 Framework of Interdisciplinary Collaboration

Framework for Interdisciplinary Collaboration: The overarching structure that outlines the essential elements for successful collaboration across different disciplines. Communication: Regular Meetings: Scheduled sessions to ensure ongoing dialogue and coordination among team members. Transparent Information Sharing: Open and clear communication channels to facilitate the exchange of ideas, updates, and feedback. Technology Integration: Collaborative Tools: Software and platforms that enable team members to work together efficiently, regardless of location. Virtual Workspaces: Digital environments that replicate the collaborative experience of a physical workspace. Team Structure: Clear Roles: Defined

responsibilities and expectations for each team member to ensure accountability and clarity in the collaborative process. Diverse Expertise: A team composed of members from various disciplines, each contributing their specialized knowledge to the project.Management Practices: Project Planning: Strategic planning to outline the objectives, timelines, and resources required for the collaboration. Conflict Resolution: Mechanisms and strategies in place to address and resolve disagreements or conflicts that may arise during collaboration.

Construction and Engineering Projects

Salam et al., (Salam et al., 2019) delves into inter-disciplinary collaboration in the detail design stage of a construction project. A study by the University of Technology Sydney looks intra-professionally at the relationships between the designers and the contractors. Salam et al., (Salam et al., 2019) discusses how to make collaboration happen and some critical success factor for that: co-location, define roles, access to information, diversity in teams and aligned incentives.

Detailed design at the other end is a stage where design intent becomes physical reality. Well-coordinated collaboration at this stage is key to making design solutions workable from a construction perspective, appropriate to the operational program and budget, and satiating to the client. The work of Salam et al., (Salam et al., 2019) is important as it underlines the necessity in interdisciplinary (ID) co-operation in construction projects of structured frameworks and the need for collaborative enablers.

Costa et al. (Costa et al., 2019) studied the use of collaborative workshops and synchronous environments to enable interdisciplinary collaboration in design initiatives. This research shows how workshops and real-time collaboration-enhancing environments could improve the communication, coordination and decision-making within a team. Interactive settings which these events offer can help facilitate hands-on participation, share experiences with others, and align and shape agreement about project mission and problems.

Collaborative workshops and synchronous environments are especially good for teamwork and innovation. These methods enable disciplinary diversity while also creating a focused environment for others. They break down communication barriers, start to form relationships built on trust, and foster a culture where working together is the norm. The research demonstrates the potential of

these techniques to promote interdisciplinary collaboration in design and engineering (Costa et al., 2019).

Factors Influencing Interdisciplinary Collaboration

How Interdisciplinary collaboration impacts interactive design projects across various determinants of team-work? Several factors that appear to have an impact on the success of interdisciplinary collaboration have been delineated through the studies included in the systematic analysis. Overcoming hurdles and creating efficient collaboration are all possible when these factors are addressed. For each key factor, we present a more lengthy summary and describe how the reviewed studies addressed those specific influences.

Communication and Coordination

Effective interdisciplinary collaboration hinges on clear communication. Studies consistently emphasize the importance of using robust communication tools and methods to facilitate seamless interaction among team members. For instance, Pokojski (Pokojski, 2020) highlight the benefits of digital collaboration tools like video conferencing and chat programs, which enable real-time communication and data sharing. These tools help bridge geographical gaps and departmental divides, enhancing team cohesion.

Costa et al. (Costa et al., 2019) underscore the role of interactive technologies in improving communication. High-resolution Powerwalls and interactive tables allow team members to collaboratively visualize and manipulate data, promoting transparency and inclusiveness. Such technologies minimize misunderstandings and provide everyone with a clear view of the project's progress and challenges.

Regular, face-to-face contact and shared visibility into project information are also crucial for effective coordination. Salam et al., (Salam et al., 2019) suggests that routine face-to-face meetings create momentum and facilitate timely decision-making. These meetings enable team members to discuss progress, address issues, and align their efforts toward common goals. Additionally, keeping project information up to date is vital. Ververidis et al. (Ververidis et al., 2022) discuss the importance of shared digital workspaces, which allow team members to access and update design documents, specifications, and cost estimates. This centralized information

repository ensures that all participants work with the same data, reducing errors and improving overall coordination.

Team Composition and Roles

Different forms of team setups contribute significantly to the richness of interdisciplinary cooperation. When a team is diverse, it includes various perspectives, talents, and expertise, leading to more creative and comprehensive solutions. Urban design projects that involve students, patrons, learners, and the urban public benefit greatly from such diversity, as highlighted by Neuman (Neuman, 2016). This diversity provides different angles to approach design problems and fosters a collaborative problem-solving culture.

To manage this complexity responsibly, clear roles and responsibilities are essential. Kaygan and Aydınoğlu (Kaygan and Aydınoğlu, 2018) emphasize the importance of well-defined roles, ensuring that all members work on common areas and responsibilities at relevant levels. This clarity prevents overlap and confusion, allowing employees to focus on their tasks and collaborate effectively with teammates.

This principle is particularly relevant in construction and engineering projects, which often include subcontractors and cross-functional teams. Salam et al., (Salam et al., 2019) points out that involving subcontractors from the design phase allows contractors to fully leverage their experience, ensuring that design solutions are practical and feasible. Cross-functional teams, comprising members from various disciplines, enrich collaboration with their wide range of expertise.

Technological Integration

Digital platforms create open, overlapping spaces for team members to communicate and share ideas while monitoring progress, as noted by Indraprastha (Indraprastha, 2023). These platforms enhance engagement and communication efficiency, enabling diverse teams to collaborate more effectively. Ververidis et al. (Ververidis et al., 2022) highlight that various VR systems offer immersive environments where team members can visualize and interact with 3D models and simulations, providing real-time data. This improves visualization and communication, helping teams identify potential issues and make informed decisions. Wang and Wu (Wang and Wu, 2022) explain that modular programming simplifies complex operations, promoting collaborative learning, especially when different teams are involved in a project.

However, the integration of technology, despite its benefits, presents challenges. Costa et al. (Costa et al., 2019) point out that adopting new technologies can involve a steep learning curve and require extensive training. Pokojski (Pokojski, 2020) also note potential compatibility and interaction issues among different digital tools. Solutions to these challenges include providing adequate training, using standardized tools to ensure compatibility, and fostering a culture of continuous learning and growth.

Project Management and Scheduling

Project management is crucial for coordinating interdisciplinary teamwork effectively. Neuman (Neuman, 2016) highlights that sound project management practices are vital, especially in service-based learning projects. These practices include setting clear goals, defining checkpoints, and monitoring progress to keep projects on track. Tools like Gantt charts and project management software assist teams in planning, executing, and tracking tasks. These visual aids help identify delays and allocate resources more efficiently.

Indraprastha (Indraprastha, 2023) acknowledges the challenges of scheduling for a global team with diverse commitments across different time zones. However, employing time management strategies such as flexible scheduling, task prioritization, and time-tracking tools can alleviate these issues. Regular progress reviews and adjustments to the project schedule are necessary to maintain momentum.

Salam et al., (Salam et al., 2019) stresses the importance of flexibility in project management. Teams must be able to adapt and shift gears when necessary to meet deadlines, demonstrating the need for a dynamic approach to managing interdisciplinary projects.

Trust and Collaboration Culture

Collaborating across disciplines relies heavily on trust. Trust fosters open communication, reduces conflicts, and enhances team commitment. According to Maric (Maric, 2019), building trust among team members is crucial for collaborative art projects. Trust develops through consistent and transparent communication, mutual respect, and shared goals over time.

In construction projects, trust is equally important, as emphasized by Salam et al., (Salam et al., 2019). Team members depend on each other's expertise and capacities, making trust essential. Informal interactions help build relationships, allowing team members to appreciate and support one another toward common goals.

A culture of collaboration is central to successful interdisciplinary teamwork. Costa et al. (Costa et al., 2019) highlight the need for a working environment that encourages teamwork, innovation, and continuous learning. This culture can be nurtured through activities like team-building exercises, maintaining open communication channels, and recognizing collaborative achievements.

Creating a conducive collaborative environment involves designing both physical and virtual spaces that facilitate interaction and engagement. Kaygan and Aydınoğlu (Kaygan and Aydınoğlu, 2018) emphasize the importance of co-located spaces, open layouts, and accessible workspaces in design education to spark informal communication and cooperation. Similarly, Ververidis et al. (Ververidis et al., 2022) discuss how digital platforms and virtual environments create online spaces that allow team members to collaborate effectively, regardless of their physical location.

Outcomes of Interdisciplinary Collaboration

Working with skilled trades on interactive design projects influences the outcomes in educational, project-specific, and social and cultural dimensions. The reviews identified in this gap analysis highlighted many benefits that the combination of different backgrounds and expertise brings to the project's effectiveness and impact. This section summarizes the findings of the studies, categorized into three parts: educational, project-specific, and social and cultural outcomes.

Unified results from the reviewed studies emphasize the importance and possibilities of interdisciplinary collaboration. Bringing various disciplines together is crucial for developing even complex design problems. Key outcomes from these studies include enhanced learning and skill development, successful project completions and innovations, and significant social and cultural impacts.

Educational Outcomes

One key measure of success in interdisciplinary collaboration is the resulting increase in student learning, seen through improved learning gains and skill development. Neuman (Neuman, 2016) argues that collaborative and interdisciplinary service-based learning projects play a critical role in translating theory into practical application. These projects help students develop essential skills such as problem-solving, team management, and leadership.

Additionally, Indraprastha (Indraprastha, 2023) emphasizes that project-based courses encourage interaction among students from different departments, fostering critical thinking and

collaborative engagement. These design projects provide opportunities for students to work together, integrating their knowledge to tackle project challenges, which enhances their understanding of the subject matter. This interdisciplinary approach not only strengthens students' technical abilities but also improves their ability to work effectively in diverse teams.

Collaborating across disciplines has a significant impact on student engagement and critical thinking. Kaygan and Aydınoğlu (Kaygan and Aydınoğlu, 2018) observe that multidisciplinary collaborative design education increases student motivation and engagement. Learning alongside individuals from various backgrounds creates a rich, dynamic learning environment that encourages active participation.

Furthermore, interdisciplinary work promotes critical thinking by requiring students to consider multiple perspectives. Indraprastha (Indraprastha, 2023) notes that well-designed interdisciplinary projects compel students to analyze and synthesize information from various disciplines, enhancing their critical and analytical skills. This process allows for the inclusion of diverse viewpoints, leading to more innovative and well-rounded solutions (Figure 6).

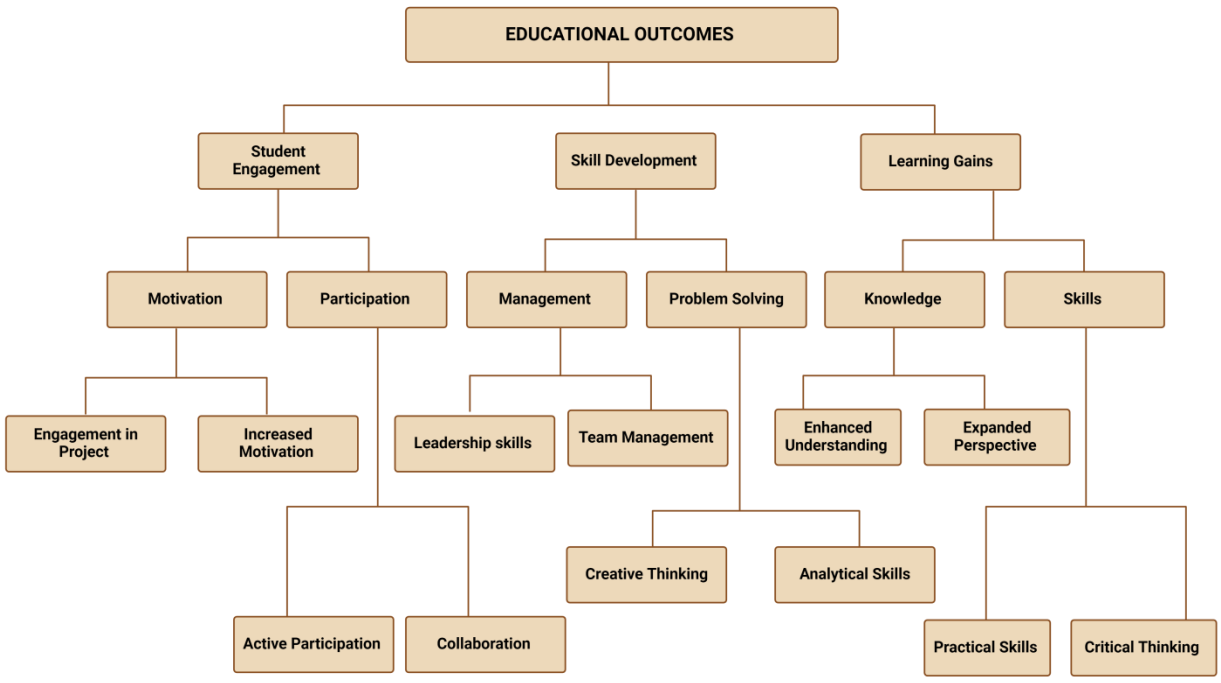

Figure 6 Educational outcomes of Interdisciplinary collaboration

Educational Outcomes: The overall category representing the desired results of educational activities, broken down into three main areas: Student Engagement, Skill Development, and Learning Gains. Student Engagement: Motivation: The drive and enthusiasm of students towards their educational activities. Engagement in Project: The level of involvement and interest students show in project-based learning. Increased Motivation: The improvement in students' willingness to participate due to engaging educational practices. Participation: The active involvement of students in their learning process. Active Participation: The extent to which students take part in learning activities. Increased Participation: The overall increase in students' engagement in various learning opportunities.Skill Development: Management: The development of organizational and leadership abilities. Leadership Skills: The ability to guide and influence others in a learning environment. Team Management: The capacity to coordinate and manage group activities effectively. Problem Solving: The enhancement of critical and creative thinking to address challenges. Creative Thinking: The ability to think outside the box and generate innovative solutions. Collaboration: The improvement of teamwork skills through cooperative learning. Learning Gains: Knowledge: The acquisition and deepening of subject-specific understanding. Enhanced Understanding: A more profound comprehension of the material. Expanded Perspective: The broadening of viewpoints and awareness of different contexts. Skills: The development of practical and intellectual abilities. Practical Skills: The hands-on abilities gained through learning activities. Critical Thinking: The refinement of analytical skills to evaluate and synthesize information effectively.

Project Outcomes

Design and construction projects can benefit greatly from interdisciplinary collaboration. Salam et al., (Salam et al., 2019) notes that effective collaboration between designers and contractors during the detailed design phase leads to more practical and viable solutions. Integrating multiple areas of expertise ensures that designs align with construction realities, increasing the chances of project success.

Similarly, Pokojski (Pokojski, 2020) discuss how digital collaboration strategies enhance communication and coordination among team members, helping to manage complex projects.

Tools like CAD, VR, and AR facilitate team-wide design visualization and refinement, reducing errors and improving overall project efficiency.

Interdisciplinary collaboration is one of the best ways to drive innovation and improve project processes. Costa et al. (Costa et al., 2019) found that interactive technologies in collaborative design projects foster creativity and innovation. These technologies allow team members to experiment with data and design elements in real time, exploring new ideas and solutions.

Ververidis et al. (Ververidis et al., 2022) also concluded that collaborative VR systems in the AEC industry improve project processes. VR provides an immersive way to visualize designs, enhancing communication as design concepts become tangible, leading to more informed decisions. This results in a smoother project workflow, making it faster and more robust (Figure 7).

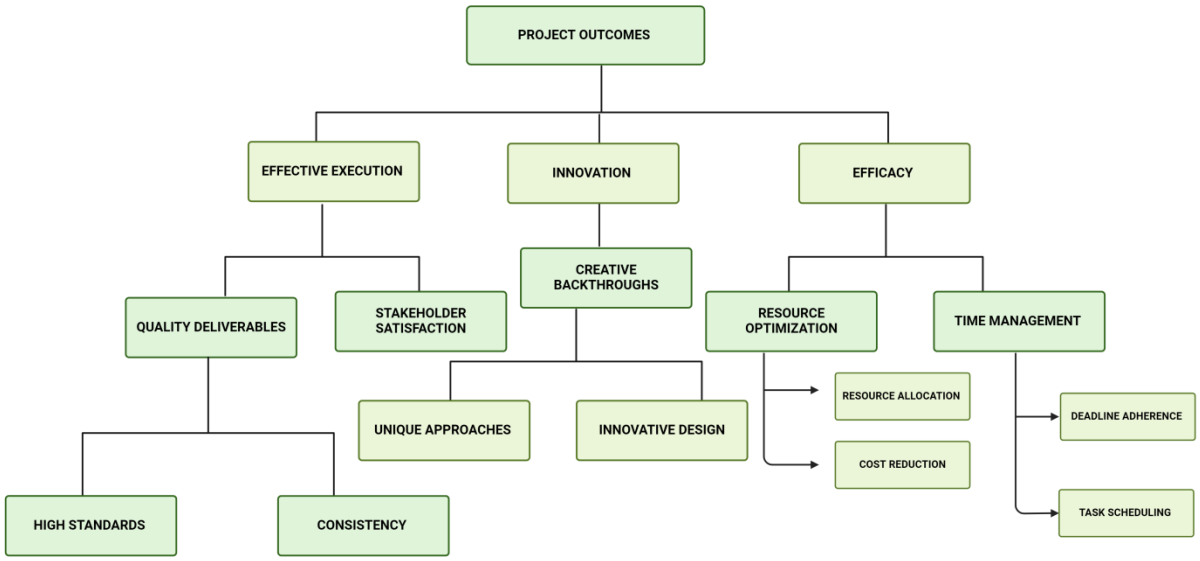

Figure 7 Project outcomes of Interdisciplinary collaboration

Project Outcomes: The overall goal or results that a project aims to achieve, segmented into three main categories: Effective Execution, Innovation, and Efficacy. Effective Execution: Quality Deliverables: Ensuring that project outputs meet or exceed expectations. High Standards: Maintaining excellence in all deliverables. Consistency: Delivering results that are reliable and uniform over time. Stakeholder Satisfaction: Meeting or surpassing the expectations of stakeholders involved in the project. Innovation: Creative Breakthroughs: The development of new

and inventive ideas within the project. Unique Approaches: Implementing novel methods or strategies that differentiate the project. Innovative Design: Introducing cutting-edge design elements that enhance the project's uniqueness. Efficacy: Resource Optimization: Efficiently managing resources to achieve the best possible outcomes. Resource Allocation: Effectively distributing resources where they are needed most. Cost Reduction: Minimizing expenses while maintaining or improving quality. Time Management: Managing time effectively to ensure project deadlines are met. Deadline Adherence: Completing tasks within the designated timelines. Task Scheduling: Organizing tasks in a manner that optimizes time usage.

Social and Cultural Outcomes

Interdisciplinary projects in interactive design often lead to collaborative efforts with a focus on social innovation and community engagement. Neuman (Neuman, 2016) highlights the impact of service-based learning projects on communities, noting that these initiatives go beyond academia. They involve students, faculty, and community clients in participatory urban design projects that address real-world needs and create social change.

Maric (Maric, 2019) discusses the social and cultural outcomes of collaborative art projects, such as the "Meet the Ministry" project, which engage young people and professional artists in activities that promote social inclusion and cultural exchange. These projects leverage interdisciplinary approaches to bridge divides within communities, enhancing overall community efficacy.

Interdisciplinary collaboration also fosters the acquisition of social capital and bridges gaps between social and professional groups. Such projects offer participants opportunities to network and collaborate across disciplines, facilitating the exchange of knowledge and resources, which in turn boosts innovation and problem-solving capabilities.

Kaygan and Aydınoğlu (Kaygan and Aydınoğlu, 2018) observe that interdisciplinary design education helps students build social capital. Collaborative projects allow students to network with peers from different fields, strengthening their professional networks for future use. These connections also enable the exchange of diverse perspectives, enriching the learning experience.

Overall, the effects of interdisciplinary interaction in interactive design projects are broad and profound. The articles mentioned underscore significant benefits to student learning, skill acquisition, and enhanced engagement and critical thinking. Furthermore, interdisciplinary work

leads to successful project outcomes, encourages creativity, and enhances project processes. This type of collaboration also serves as a form of social and cultural intervention, generating social innovation, social capital, and community participation. By understanding and promoting these outcomes, practitioners and educators can make interdisciplinary collaboration more effective and achieve positive results in interactive design projects (Figure 8).

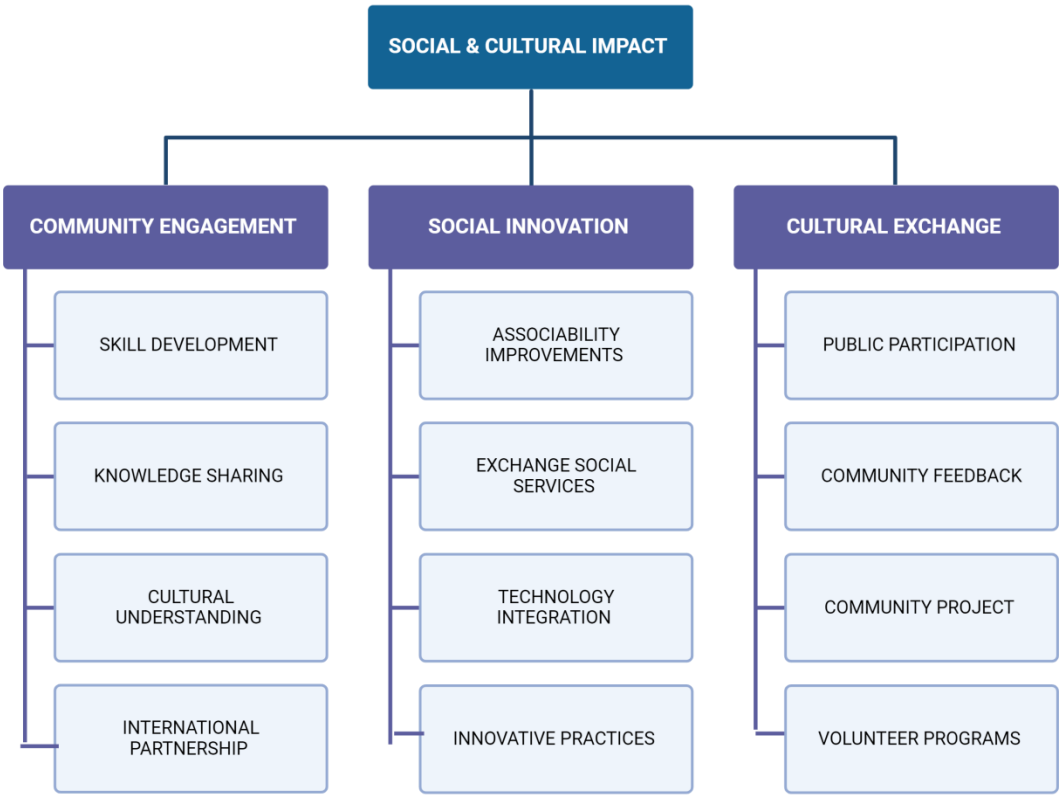

Figure 8 Social and Cultural outcomes of Interdisciplinary collaboration

Social & Cultural Impact: The overarching goal of fostering positive changes and exchanges within society and across cultures, segmented into three main areas: Community Engagement, Social Innovation, and Cultural Exchange. Community Engagement: Skill Development: Enhancing the abilities and competencies of community members. Knowledge Sharing: Facilitating the exchange of information and expertise within the community. Cultural Understanding: Promoting awareness and appreciation of diverse cultural backgrounds. International Partnership: Building collaborations between communities across different countries. Social Innovation: Associability Improvements: Enhancing the ability of community members to form connections and networks. Exchange Social Services: Implementing new

methods of providing and exchanging social services within the community. Technology Integration: Incorporating modern technologies to improve community services and interactions. Innovative Practices: Introducing and adopting novel approaches to address social challenges. Cultural Exchange: Public Participation: Encouraging active involvement of the public in cultural activities and events. Community Feedback: Gathering input from the community to guide cultural initiatives and exchanges. Community Project: Organizing and executing projects that foster cultural collaboration and learning.Volunteer Programs: Creating opportunities for individuals to engage in cultural exchange through volunteer work.

Discussion

The literature review on interdisciplinary collaboration in interactive design projects has uncovered several crucial insights, highlighting the intricate and multifaceted nature of such collaborations. These insights reveal both the potential benefits and the challenges of interdisciplinary teamwork.

One key finding is that experiential learning through interdisciplinary collaboration significantly enhances student learning and skill development. Project-based and service-based learning approaches are highly effective in bridging the gap between classroom theory and real-world practice (Maeder, 2022). This method not only enriches the educational experience but also equips students with the tools to tackle real-world problems in their professional careers (Li et al., 2023). Interdisciplinary collaboration also helps to reduce risks and accelerate the delivery of design and construction projects (Engebø et al., 2020). Integrating a diverse set of skills ensures that design intentions are practical and achievable, resulting in a dynamic and efficient process (Ferme et al., 2018). This blend of experience and insight leads to more innovative solutions and overall project improvement.

Additionally, these projects foster social innovation and community engagement. By involving a diverse group of participants, they promote social inclusion, intercultural exchange, and the creation of social capital. Such engagement not only benefits the project in the short term but also helps build long-term relationships, fostering a sense of community and mutual understanding among participants (Levasseur et al., 2022).

Effective communication tools and a balanced number of meetings are essential for successful collaboration (Mattessich and Johnson, 2018). Digital workspaces and real-time collaboration technologies enable team members to interact and coordinate effortlessly (Banit et al., 2023). These tools help manage the complexities of multidisciplinary teams, ensuring that everyone remains aligned and works effectively toward the project's goals.

Digital platforms, VR, and modular programming further enhance interdisciplinary collaboration (Qiao et al., 2021). These technologies improve visualization, communication, and problem-solving capabilities, although they also present challenges related to training and compatibility. Addressing these challenges is crucial to fully realize the potential of these technologies in collaborative settings (Parti and Szigeti, 2021).

The success of interdisciplinary collaboration depends on team diversity and clearly defined roles (Haeussler and Sauermann, 2020). Early involvement of subcontractors and cross-functional teams broadens the knowledge base and enhances the collaborative process. Clear role definitions help manage diverse perspectives, prevent overlap and confusion, and ensure that all team members can contribute effectively (Saint-Pierre et al., 2018).

The findings of this review align with and expand on existing interprofessional literature. Previous studies have highlighted the importance of integrating diverse perspectives and expertise to address complex design challenges (Meyer and Norman, 2020, Morel and Spector, 2022, Tobi and Kampen, 2018, Noyes et al., 2019). This review supports these findings and emphasizes the specific benefits of interdisciplinary collaboration in interactive design projects. Additionally, it offers new insights into the role of emerging technologies like VR and modular programming in enhancing collaboration. When these technologies are successfully integrated, they can significantly improve collaborative practices.

The implications of these findings are practical for educators, practitioners, and researchers involved in collaborative design projects. Understanding the factors that contribute to successful interdisciplinary collaboration can help stakeholders refine their processes to achieve desired outcomes. Recommendations for enhancing interdisciplinary collaboration include investing in communication technologies and training, fostering a collaborative culture, leveraging a variety of technologies, promoting team diversity and role clarity, implementing structured project

management practices, and building trust among team members. These strategies will create an environment where interdisciplinary collaboration thrives, leading to higher project success.

Conclusion

For interactive design projects, interdisciplinarity is not just a beneficial approach; it is essential. These projects are inherently complex and multifaceted, requiring a broad perspective to address the numerous challenges they present. Interdisciplinary teams bring together professionals from various fields, enabling them to develop more effective solutions than single-discipline teams could achieve.

Beyond addressing technical and logistical aspects, interdisciplinary collaboration cultivates a culture of continuous learning and innovation within the team. It encourages members to share knowledge, challenge assumptions, and experiment with new ideas. This openness and collaborative spirit are crucial for advancing the discipline and pushing the boundaries of interactive design.

Moreover, interdisciplinary work promotes social and cultural well-being. Projects that embrace this approach are not only more successful in achieving their goals but also tend to align with broader societal objectives, such as social inclusion, cultural exchange, and community development. They help build connections among different social and professional groups, fostering a sense of community and shared interest.

Interdisciplinary collaboration significantly enhances the outcomes of interactive design projects. Continued research and development in this area will help unlock its full potential, driving innovation and improving project results while fostering greater social and cultural enrichment. The insights gained from this review provide a valuable foundation for future research and development, which will ultimately strengthen interdisciplinary partnerships and their effectiveness in the future.

Future Research

Despite the findings from this review demonstrating the positives and influencing factors of interdisciplinary collaborations in interactive design projects, there is a need for ongoing work in this domain. Several key areas warrant further exploration to extend and develop our current knowledge and practice of interdisciplinary collaboration.

1. **Longitudinal Research on Educational Impacts**: Future research should investigate the potential impacts of cross-disciplinary models of cooperation in education on students' career trajectories and professional development. Educators and practitioners can benefit from understanding how collaborative experiences affect career choices and success.
2. **Technological Integration Progression**: Future research is necessary to evaluate the integration of new technologies like VR and modular programming in interdisciplinary work. Studies should determine best practices, address compatibility issues, and assess the impact of these technologies on collaborative processes and outcomes.
3. **Cross-Cultural and Cross-Disciplinary Studies**: Given that interdisciplinary collaboration generally involves participants from diverse cultural backgrounds and disciplines, the effects of cultural and disciplinary diversity on collaborative processes and outcomes should be further examined. Understanding how to increase collaboration in diverse teams can greatly impact the potential of utilizing a wide array of talented people.
4. **Impact on Innovation and Project Success**: More studies are needed to measure how interdisciplinary collaboration contributes to innovation and project success. Research should focus on understanding the mechanisms through which collaboration drives innovation and the contexts that enhance or diminish this effect.
5. **Development of Collaboration Frameworks**: There is a need to develop frameworks and models that guide interdisciplinary ways of working. These frameworks should incorporate best practices, address common challenges, and provide actionable insights for team leaders working across different domains.

References:

AFTAB, M., BAILEY, M., SPENCER, N., JEFFS, C., SMITH, N., STALKER, B. & SAMS, P. 2015. A multidisciplinary approach to innovation. *The Innovation & Entrepreneurship Teaching Excellence Awards 2015***,** 1-14.

BANIT, O., ROSTOKA, M., RAIEVSKA, Y., KRAVCHUK, O. & CHEREVYCHNYI, G. Digital collaboration of virtual project teams in the transdisciplinary educational space. AIP Conference Proceedings, 2023. AIP Publishing.

BLANDFORD, A., GIBBS, J., NEWHOUSE, N., PERSKI, O., SINGH, A. & MURRAY, E. 2018. Seven lessons for interdisciplinary research on interactive digital health interventions. *Digital health,* 4**,** 2055207618770325.

CARR, G., LOUCKS, D. P. & BLÖSCHL, G. 2018. Gaining insight into interdisciplinary research and education programmes: A framework for evaluation. *Research Policy,* 47**,** 35-48.

CASCINI, G., GRAZIOSI, S., MONTAGNA, F. & ROTINI, F. 2017. On the factors affecting design education within a multi-disciplinary class. *Journal of Integrated Design and Process Science,* 21**,** 21-44.

CHASANIDOU, D., GASPARINI, A. & LEE, E. Design thinking methods and tools for innovation in multidisciplinary teams. Workshop Innovation in HCI. Helsinki, Finland: NordiCHI, 2014. 27-30.

COSTA, A., THOMANN, G. & NOËL, F. 2019. Interactive technologies facilitating collaboration between projetists and non-projetists: A laboratory design experience. *Procedia CIRP,* 84**,** 55-60.

ENGEBØ, A., KLAKEGG, O. J., LOHNE, J. & LÆDRE, O. 2020. A collaborative project delivery method for design of a high-performance building. *International Journal of Managing Projects in Business,* 13**,** 1141-1165.

FERME, L., ZUO, J. & RAMEEZDEEN, R. 2018. Improving collaboration among stakeholders in green building projects: Role of early contractor involvement. *Journal of Legal Affairs and Dispute Resolution in Engineering and Construction,* 10**,** 04518020.

GAO, X., LI, P., SHEN, J. & SUN, H. 2020. Reviewing assessment of student learning in interdisciplinary STEM education. *International Journal of STEM Education,* 7**,** 1-14.

HAEUSSLER, C. & SAUERMANN, H. 2020. Division of labor in collaborative knowledge production: The role of team size and interdisciplinarity. *Research Policy,* 49**,** 103987.

HAVNES, A. & SMEBY, J.-C. 2014. Professional development and the profession. *International handbook of research in professional and practice-based learning***,** 915-954.

HEITZMANN, N., OPITZ, A., STADLER, M., SOMMERHOFF, D., FINK, M. C., OBERSTEINER, A., SCHMIDMAIER, R., NEUHAUS, B. J., UFER, S. & SEIDEL, T. 2021. Cross-Disciplinary Research on Learning and Instruction–Coming to Terms. *Frontiers in Psychology,* 11**,** 562658.

INDRAPRASTHA, A. 2023. Fostering Critical Collaborative Thinking through Digital Platform: An Empirical Study on Interdisciplinary Design Project. *International Journal of Built Environment and Scientific Research,* 7**,** 19-30.

KAYGAN, P. & AYDıNOĞLU, A. U. 2018. The role of space in interdisciplinary collaboration in design education. *International Journal of Technology and Design Education,* 28**,** 803-817.

KLAASSEN, R. G. 2018. Interdisciplinary education: a case study. *European journal of engineering education,* 43**,** 842-859.

LEVASSEUR, M., LUSSIER-THERRIEN, M., BIRON, M. L., RAYMOND, É., CASTONGUAY, J., NAUD, D., FORTIER, M., SÉVIGNY, A., HOUDE, S. & TREMBLAY, L. 2022. Scoping study of definitions of social participation: Update and co-construction of an interdisciplinary consensual definition. *Age and ageing,* 51**,** afab215.

LI, W., BIAN, J., LEE, C., BOLOGAN, A., CHASPARI, T., CALVESBERT, T., MASTERSON, J., STILLISANO, J., WRIGHT, K. & SHIELDS, S. 2023. Interdisciplinary and Project-Based Service Learning for Smart and Connected Communities: Insights from ENDEAVR. *Journal of Interdisciplinary Studies in Education,* 12**,** 304-334.

MAEDER, J. J. 2022. *The Effectiveness of Project-Based Learning and Exploring Theories Supporting 21st Century Learning Methods.* Baker University.

MARIC, J. The challenges of designing the interaction design of a collaborative art project. The 18th International Conference on WWW/Internet, 2019. 28-43.

MATTESSICH, P. W. & JOHNSON, K. M. 2018. Collaboration: What makes it work.

MEYER, M. W. & NORMAN, D. 2020. Changing design education for the 21st century. *She Ji: The Journal of Design, Economics, and Innovation,* 6**,** 13-49.

MOIRANO, R., SÁNCHEZ, M. A. & ŠTĚPÁNEK, L. 2020. Creative interdisciplinary collaboration: A systematic literature review. *Thinking Skills and Creativity,* 35**,** 100626.

MOREL, G. M. & SPECTOR, J. M. 2022. *Foundations of educational technology: Integrative approaches and interdisciplinary perspectives*, Routledge.

NEUMAN, M. 2016. Teaching collaborative and interdisciplinary service-based urban design and planning studios. *Journal of Urban Design,* 21**,** 596-615.

NOYES, J., BOOTH, A., MOORE, G., FLEMMING, K., TUNÇALP, Ö. & SHAKIBAZADEH, E. 2019. Synthesising quantitative and qualitative evidence to inform guidelines on

complex interventions: clarifying the purposes, designs and outlining some methods. *BMJ global health,* 4**,** e000893.

PAGE, M. J., MCKENZIE, J. E., BOSSUYT, P. M., BOUTRON, I., HOFFMANN, T. C., MULROW, C. D., SHAMSEER, L., TETZLAFF, J. M., AKL, E. A. & BRENNAN, S. E. 2021. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *Bmj,* 372.

PARTI, K. & SZIGETI, A. 2021. The future of interdisciplinary research in the digital era: obstacles and perspectives of collaboration in social and data sciences-an empirical study. *Cogent Social Sciences,* 7**,** 1970880.

POKOJSKI, J. Evaluation and development of digital collaboration techniques for interdisciplinary collaboration. Transdisciplinary Engineering for Complex Socio-technical Systems–Real-life Applications: Proceedings of the 27th ISTE International Conference on Transdisciplinary Engineering, July 1–July 10, 2020, 2020. IOS Press, 415.

PRESTES JOLY, M., TEIXEIRA, J. G., PATRÍCIO, L. & SANGIORGI, D. 2019. Leveraging service design as a multidisciplinary approach to service innovation. *Journal of service Management,* 30**,** 681-715.

QIAO, J., XU, J., LI, L. & OUYANG, Y.-Q. 2021. The integration of immersive virtual reality simulation in interprofessional education: A scoping review. *Nurse Education Today,* 98**,** 104773.

RAZMAK, J. & BÉLANGER, C. H. 2016. Interdisciplinary Approach: A Lever to Business Innovation. *International Journal of Higher Education,* 5**,** 173-182.

REEVES, S., GOULDEN, M. & DINGWALL, R. 2016. The future as a design problem. *Design Issues,* 32**,** 6-17.

SAINT-PIERRE, C., HERSKOVIC, V. & SEPÚLVEDA, M. 2018. Multidisciplinary collaboration in primary care: a systematic review. *Family practice,* 35**,** 132-141.

SALAM, M., FORSYTHE, P., KILLEN, C. & ABD AL SALAM, M. Exploring interdisciplinary collaboration in the detailed design phase of construction projects. Annual Conference of the International Group for Lean Construction, 2019.

SZALAPAJ, P. 2014. *Contemporary architecture and the digital design process*, Routledge.

TOBI, H. & KAMPEN, J. K. 2018. Research design: the methodology for interdisciplinary research framework. *Quality & quantity,* 52**,** 1209-1225.

TYTLER, R., WILLIAMS, G., HOBBS, L. & ANDERSON, J. 2019. Challenges and opportunities for a STEM interdisciplinary agenda. *Interdisciplinary mathematics education: The state of the art and beyond***,** 51-81.

VERVERIDIS, D., NIKOLOPOULOS, S. & KOMPATSIARIS, I. 2022. A review of collaborative virtual reality systems for the architecture, engineering, and construction industry. *Architecture,* 2**,** 476-496.

WANG, C.-H. & WU, K.-C. 2022. Interdisciplinary Collaborative Learning with Modular Programming and Information Visualization of Urban Smart Spaces.