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DESIGNING LEARNING ACTIVITIES TO IMPROVE UNDERGRADUATE STUDENT COLLABORATIVE PROBLEM-SOLVING SKILLS IN THE MULTIDISCIPLINARY COURSE IN THE POSTDIGITAL EDUCATIONAL LANDSCAPE

Master thesis

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Abstract

This thesis explores the approach to teaching and assessing collaborative problem-solving skills to undergraduate students in the multidisciplinary course. In the study, a large class of 59 students participated in four learning activities involving well- and ill-defined problems. The research findings indicate that students benefited more from well-structured and instructed tasks; on the other hand, ill-defined tasks exposed students to more opportunities and challenges to learn how to solve real-life problems collaboratively. The assessment was amenable to evaluating a variety of tasks focusing on capturing behaviour and the CPS skills across assignments and team members. The combination of assessment method mitigated the limitations of validity and reliability of the measures.

Keywords

Collaborative problem-solving, assessment, task and idea oriented scaffolds, postdigital, higher education.

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Introduction

Higher Education is embracing the challenges of addressing the ever-evolving needs of the real business world. Employers expect job-ready graduates with well-developed "soft" and "hard" skills to innovate and solve complex problems. However, despite business school programs emphasising soft skills like teamwork, communication, and problem-solving, there remains significant criticism from employers and a lack of evidence on the efficacy of these teaching efforts in preparing students to tackle real-life complex problems (Thomas et al., 2021; Longmore et al. 2018, as cited in Mainga et al., 2022). Pearson's research (Pearson, 2022) confirms this shift in the demand for human skills, listing collaboration skills as among the top five most mentioned skills in job ads. The research AI-based modelling suggested that collaboration skills will be among the top-demand skills by the end of 2026. The ability to work in a team has been seen as a life-taught skill, but effective collaboration varies among individuals and requires dedicated teaching efforts (Schoenfeld, 1999, as cited in Hesse et al., 2015). PISA 2015 (OECD, 2017) defines collaborative problem-solving (CPS) as the capacity of individuals to engage effectively in a process where multiple agents solve a problem by sharing understanding, effort, and pooling their knowledge and skills. The PISA 2015 report highlighted the weaknesses in current teaching practices in developing students' competence to collaborate efficiently, a skill highly sought after by employers. This deficiency has sparked discussions about embedding CPS and related teamwork elements into curricula at all educational stages (Graesser, 2020). Applying action research to improve teaching practices could create a learning space that enhances students' collaborative problem-solving abilities (OECD, 2017). Many researchers have investigated variables influencing the formation of collaboration and problem-solving skills (Johnsen et al., 2023; Halttunen T. et al., 2023). However, ongoing debates about frameworks, assessment approaches, and instructional practices present significant challenges in selecting suitable pedagogical methods (Pásztor-Kovács et al., 2020; Griffin & Care, 2014; Sun et al., 2019). Few business school scholars (McKendall, 2000; Johnsen M. et al., 2023) have studied the development of CPS skills in large-scale studies, revealing practical challenges in constructing activities using theoretical frameworks and addressing biases in self-reported data. The author uses action research to identify course deficiencies, design CPS-enhancing modifications for the postdigital educational landscape, and evaluate their effectiveness in improving undergraduate ability to collaboratively address social-value problems.

Theoretical Overview

Postdigital in Education

Over the past decade, several studies (Cramer, 2014; Jandrić et al., 2018; Fuller & Jandrić, 2019) have explored the educational landscape in the postdigital era, where technologies became seamlessly embedded in everyday practices. Fuller and Jandrić (2019) describe this era's educational landscape as a hybrid of digital and analogue media, forming an ecosystem of electronic devices, network systems, social media platforms, and applications that support the collection, sharing, and repurposing of learner data. Despite the digital domain shaping the learning context, the academic community has not sufficiently researched the essential role of discrete and continuous data in driving technology. This is particularly relevant to AI-based technologies, which are becoming a central topic in academic discussions. Shannon (2021) highlights that developing digital products, which lack visible spatial presence, relies on team collaboration to maintain a shared understanding of ongoing processes. This is supported by Fiore et al. (2014), who found that team knowledge-building processes accounted for about 50% of the data in NASA's Mission Control Centre, emphasising collaborative problem-solving's importance in critical environments.

Drawing on Jandrić et al. (2018), the data processing cycle (input-process-output) is integral to the postdigital ecosystem in a business school, leveraging diverse materials for students and multidisciplinary course instructors. Adopting a postdigital learning practice requires a shift from domain knowledge focus and teaching-to-test approaches to a process-driven learning model. Several authors (Gratani et al., 2023; Ioannou & Gravel, 2024) have applied social learning and constructivism theories based on the Maker Education approach. This strategy facilitates transitioning from traditional and blended learning to a postdigital environment filled with diverse materials—digital, analogue, and physical. This method prioritises how digital technologies mediate, facilitate, and co-design the learning process, emphasising their role in supporting critical thinking, problem-solving, and collaboration.

By advancing 21st-century competencies, this approach enables learners to co-create learning processes by making, designing, and sharing meaningful artefacts. This active immersion in cross-disciplinary contexts makes scientific knowledge more accessible and applicable to real-world problems, enhancing the overall educational experience in the postdigital era.

Definitions

Several researchers have attempted to define collaborative problem-solving (CPS). From the setting of small group dedicated interaction to achieve the desired state (Kyllonen, 2012, as cited in Oliveri M.E. et al., 2017) to negotiating ideas, coordinating behaviours and applying social strategies to facilitate the interpersonal exchange to deal with a common problem (Dignler, 2017), to learning actions to build mutual understanding of a shared problem combining group's efforts, expertise and skills to develop a remedy to a problem (Barron, 2000; Fiore et al., 2017, Hmelo-Silver, 2004, as cited in Ouyang et al., 2021) till coordinated sharing of knowledge and skills between two and more people for the purpose to construct a unified solution (OECD, 2017; Rochelle & Teasley, 1995, as cited in C. Sun et al., 2020).

The fundamental pre-requisite for the CPS opportunity to emerge is that a single individual cannot resolve the problem or task alone and that collaboration of various stakeholders with a unique bundle of skills, abilities, and knowledge is essential for achieving the objective. The higher the complexity of the problem or issue, the more complex the challenges are to understand, analyse, and find an answer. Another unique characteristic is that the CPS process is driven by its unique context, which is situational, and the display of sub-skills is not attached to any particular stage of the problem-solving process.

Collaboration offers benefits like improved quality through labour division, diverse knowledge, emergent ideas from team interactions, and enhanced concept evaluation. However, it also faces drawbacks such as inefficient communication, social loafing, diffusion of responsibility, and conflicts that hinder productivity. Alves et al. (2012) found that in project-based learning, students valued social competency development and knowledge sharing but noted issues like unfair grading, group disagreements, role adoption difficulties, mismatched effort and score expectations, and tutor role ambiguity.

Frameworks for the CPS skills

Most theoretical frameworks for CPS feature two primary components: (a) the collaborative, communicative, or social facets integrated with (b) the cognitive aspects of problem-solving (Graesser et al., 2018). Despite CPS being acknowledged as a vital skill for learning in the 21st century, its developmental progression remains poorly grasped (Scoular et al., 2017, as cited in Pöysä-Tarhonen, J., 2018). According to Hesse et al. (2015), CPS comprises two main skill domains: social and cognitive. The social skills focus on readiness to share, social regulation, and considering others' viewpoints, while cognitive skills involve task regulation and knowledge construction (Hesse et al., 2015; Pöysä-Tarhonen et al., 2018). Educational testing programs like PISA (OECD, 2017a) and ATC21S (Griffin & Care, 2015) emphasise CPS's social (collaboration) and cognitive (task work, problem-solving) dimensions. PISA uses a human-to-agent approach, and ATC21S uses human-to-human interaction, both assessing CPS skills on an individual level (Sun et al., 2019; Hesse et al., 2015; OECD, 2017a). Pásztor-Kovács et al. (2023) and Roschelle and Teacley (1995, as cited in Sun, 2020) highlighted the limitations of computer-mediated scenarios, lacking nuanced dynamics and potential for leadership. Pásztor-Kovács et al. (2023) enhanced computer-mediated CPS assessments by integrating visual and audio messages to increase ecological validity. Other researchers, like Olivier et al. (2017), focused on bridging the gap in generalisability by emphasising teamwork, communication, leadership, and problem-solving in CPS taxonomies.

The choice of framework

Within the present action research conducted in a large-scale class of 59 students, the author would like to apply the competence model Sun C. et al. (2020) developed for the triad set. The established interdependence of two main aspects, cognitive and social, distinguishes it from the other frameworks (PISA, ACT21S). The approach focuses on assessing the outcome of the CPS process vs the skill assessment in the context of the below-mentioned frame.

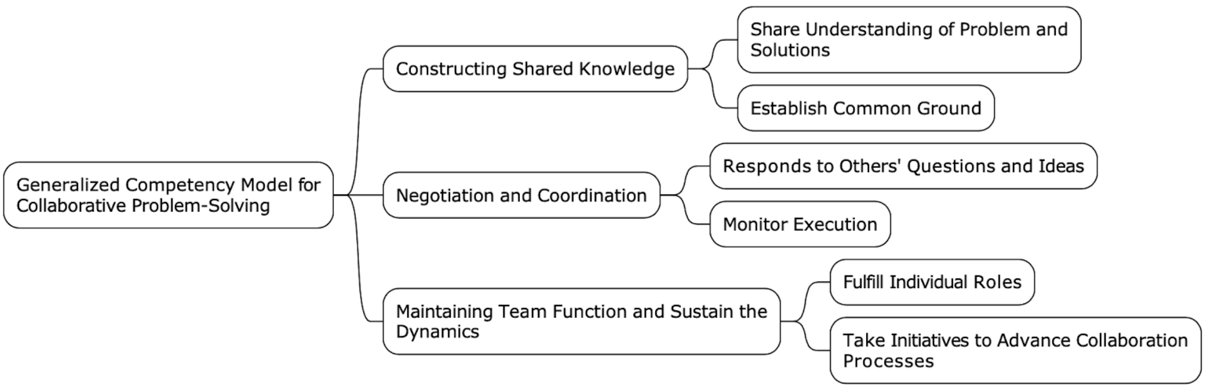

Figure 1: The main facets and sub-facets of Sun C. et al. CPS framework.

Main points of the framework (Sun C. et al., 2020):

Constructing Shared Knowledge: Emphasises exchanging ideas and establishing common ground by proposing solutions and promptly addressing misunderstandings. Negotiation and Coordination: Involves equitable task division and considering different perspectives, requiring effective communication, reasoned feedback, and strategy adaptation for task completion. Maintaining Team Function: Focuses on distributing responsibility and fostering a positive team dynamic through proactive behaviours, encouragement, and supportive communication.

Assessment methods

Evaluating CPS skills has a long and varied history, integrating approaches from cognitive psychology, business, computer science, Education, and other fields. This diversity reflects its interdisciplinary nature and the use of different theoretical and methodological approaches (Han et al., 2023). The majority of the research has been using computer solutions with well-defined problems in dyadic settings (Tower of Hanoi, Olive Oil task, ATC21S; CRESS, MycroDYN - Pasztor-Kovacs et al., 2023; Physics Playground - Sun et al., 2020). Reasoning that individual patterns of problem-solving can be better understood and computationally modelled using pre-defined text, rules and prompted judgements. A review by Oliveri M. et al. (2017) examined primary teamwork assessment instruments in HEI, including individual self-assessments, situational judgment tests (SJTs), and third-party evaluations. Group assessments involved observational tools and blended approaches. Self-assessments using Likert scales or forced-choice formats are common for measuring interpersonal and intrapersonal abilities essential to CPS skills. These assessments ask individuals to rate their preferences, beliefs, and actions related to teamwork and problem-solving (Han A. et al., 2023). However, Oliveri et al. (2017) note that biases can affect the credibility of self-assessment results. Kruger and Dunning (1999) highlighted that individuals often misjudge their abilities, with incompetence leading to overestimation and competence leading to underestimation of skills. This research will use a combination of self-assessments, teamwork assessment, situational judgement test (SJT), and observation. SJTs inspired by Freudenstein et al. (2018; 2020) assess collaboration skills by presenting work-related scenarios requiring test-takers to choose from potential behavioural responses (Goerke & Maier, 2022; Han et al., 2023; Reznik et al., 2023).

Task and idea-oriented scaffolds

The challenges of teaching and facilitating the learning process to develop CPS skills through various scaffolding strategies in both digital and traditional classroom environments have been the subject of numerous studies (Hmelo-Silver & DeSimone, 2013; Hong & Lin, 2019; Kirschner et al., 2006, as cited in Ouyang et al., 2021). Ouyang et al. (2021) provided a comprehensive understanding of how different scaffolding methods, such as task- and idea-oriented, contribute to learning complex skills in the context of ill-defined social value problems. Task-oriented and idea-oriented scaffolds represent two fundamental strategies instructors can employ to facilitate CPS activities. Task-oriented scaffolding involves structured group activities with specific techniques like division of labour and role-playing to enhance collaborative work efficiency, exemplified by the Jigsaw instruction method. On other hand, idea-oriented scaffolding focuses on less-structured, flexible interactions around generating, developing, and synthesising ideas, encouraging self-organised group dynamics.

While both approaches aim to support collaborative learning, empirical studies reveal mixed effects on learning outcomes, with idea-centred approaches sometimes leading to enhanced collaborative competencies and idea improvement, yet both incorporating inevitable overlaps in routines and knowledge advancement, highlighting the complexity and challenges in effectively integrating these scaffolds into the instructional design (Ouyang et al., 2021). At the same time, Ouyang et al. (2021) suggest that idea-oriented scaffolds require much more time and improved student self-regulation to shift towards effective idea-centred collaborative learning.

Simulations

Simulations are used in various educational fields, including STEM, and are perceived as more engaging and realistic, considering both the environment, computer-simulated and on-site. Cognitive outcomes from these activities are linked to developing knowledge structures that connect game-based activities with cognitive skills improvement. However, the effectiveness of games and simulations in education remains debated among scholars, with studies showing mixed results compared to traditional learning methods. Behaviourally, simulations have improved teamwork, relational abilities, and other soft skills, such as project management and leadership, leveraging real-life scenarios for hands-on learning (Vlachopoulos & Makri, 2017). Simulation games, which can be computer-based, non-computer-based, or hybrid, simulate aspects of reality and promote problem-solving skills by requiring players to apply knowledge, skills, and strategies in various roles to achieve game objectives. They offer many learning benefits and enhance soft skills such as task management (Leemkuil et al., 2000; Wong et al., 2022). However, Rannastu-Avalos et al. (2022) revealed that asynchronous digital tasks can create prolonged confusion, hindering learning and resulting in frustration and disengagement. This highlights the delicate balance required in designing collaborative tasks, where effective teams focus on critical interdependencies for success. In this study, the author will use task- and idea-oriented scaffolds, such as a computer-based simulation "Seesaw" to teach students to collaborate (Rannastu-Avalos et al., 2022), the Egg Drop Challenge (Ferguson et al., 2010), and the Tallest Tower Building (Rose, A. The Tallest Tower Challenge), which are widely used to teach STEM, foster collaboration among students, and build upon unique knowledge.

Research Problem and Justification

This action research project aims to enhance collaborative problem-solving skills in the "First Year Seminar" for first year students of Bachelor studies in 'Business Administration' and 'Computer Science and Organisational Technologies'. The upgraded course focuses on replacing task completion with solving an authentic social value problem, and facilitating the development of five essential social skills: collaborative problem-solving, critical thinking, creative thinking, effective communication, and efficient interaction. External stakeholders, including reginal municipality, involve in contextualising the learning objectives, ensuring real-world relevance. Previously, collaboration skills were introduced with relatively moderately dedicated instruction and not explicitly assessed. The new approach will include triple validation through student self assessments, instructors' feedback and problem owner's evaluations of solution prototypes.

Research Objective and questions

This study aims to evaluate the effectiveness of designed learning activities in improving CPS skills among undergraduate students in a multidisciplinary course.

(R1) How can collaborative problem-solving-based learning activities scaffold undergraduate students in learning to solve a complex social value problem? This research question is focused on how to teach and facilitate the CPS skills.

(R2) What is the effectiveness of the different types of CPS assessments (individual self-assessment, situation judgemental test, and teamwork assessment) adopted for use in the course? This research question is primarily targeting evaluation methodology of the CPS, aka, how to assess what has been taught and learnt.

(R3) What specific challenges are encountered by instructors in designing and delivering learning activities for teaching CPS skills within a multidisciplinary course, and how do these challenges impact students' ability to develop and apply these skills? This research question is focused on exploring the challenges and their influence students' ability to learn and succeed in applying the CPS skills.

The study's findings are expected to contribute significantly to the discourse on effective pedagogical strategies for developing CPS skills in higher education. This research will provide educators with evidence-based insights into optimising learning activities for CPS skill development by testing and evaluating the impact of scaffolding on student learning outcomes and validating the assessment tools.

Methodology

This chapter will elaborate on the action research and quantitative methods used in this study, including a description of participants, the materials used for the testing, and how the data were collected. By exploring the action research and data analysis methods used, the reader will understand how the study's data was collected and analysed to reflect on and suggest the necessary revisions of the designed learning activities for the next iterative cycle.

Action Research

Educational action research has deep roots in the work of Lewin (1946, as cited in McCutcheon and Jurg, 1990) and Collier (1945, as cited in McCutcheon and Jurg, 1990), who introduced the concept of "action" in research to address social challenges and improve group relations within educational settings, involving schools, teachers, parents, and students. Lewin's pioneering approach in action research established educational settings as vital research venues, significantly influencing critical theory and pedagogy and promoting robust, teacher-led methodological developments. Collier advocated for participatory research, empowering individuals to tackle their own needs.

Carr & Kemmis (2003) and Kemmis et al. (2014) both described action research as a reflective endeavour aimed at enhancing practices, comprehension, and situations within social or educational realms through iterative cycles of action, evaluation, and refinement, all within ethical frameworks to advance broader social science objectives. While both agree on these core elements, they differ in their focus on the research process's structure: Carr & Kemmis (2003) emphasise its adaptability through a dynamic "spiral of cycles" that fosters flexibility in addressing complex social situations, whereas Kemmis et al. (2014) advocate for a more structured and systemic approach, highlighting the importance of collective and collaborative efforts. The critical perspective on the action research practice is found in the work of McNiff (2013), who argues that for many practitioners, influenced by the methodological traditions of the social and physical sciences, the action research is concerned with the question of finding out if doing X will cause Y to occur. McNiff (2013) emphasises that action research focuses on embracing life's uncertain, transformative nature and challenging boxed-in thinking. Brydon-Miller et al. (2003) concur with the McNiff view, pointing out the deficiencies of traditional teacher training, which often prioritises discipline-specific knowledge and hierarchical structures over interdisciplinary and community-engaged research efforts. Mertler (2017) outlines an action research methodology that proceeds through four phases: planning, action, development, and reflection. Mertler asserts that within the initial planning phase, researchers align practical issues with existing academic studies to formulate a plan for investigation. Subsequently, during the action phase, this plan is executed alongside the gathering and examination of data. The development phase then involves creating a strategy to address the initial practical issue, following the data's interpretation. Lastly, the reflection phase involves a contemplative review of the entire action research cycle, setting the stage for further cycles. The importance of action research in the light of educator competence improvement was highlighted by Ernie Stringer, as cited in the work of Brydon-Miller et al. (2003).

Research method framework

Action research is particularly relevant for this study as it addresses a unique practitioner gap; previously, it has not been conducted in this higher educational institute. The focus is on reexamining and upgrading a part of teaching teamwork within the existing course by integrating CPS skills, which is crucial given the multidisciplinary curriculum. As the author steps in to substitute one of three co-instructors who responsible for teamwork skills, this method provides an invaluable tool for a detailed exploration of the new learning activities and tools. It facilitates a critical assessment of how these skills are embedded across two programs, and their impact on student learning. The author applies the combination of Lewin's spiral model (Lewin, 1946, as cited in McCutcheon and Jurg, 1990) and Riel's model (Mertler, 2017) for the developing the learning materials and assessment tools.

Participants and context

The study's participants were 59 first-year students aged 19-20 years old from the undergraduate programs in Business Administration and Computer Science and Organisational Technologies (Table 1).

Undergraduate program’s name	Male	Female	Total
Business Administration	23	19	42
Computer Science & Organisational Technologies	13	4	17

Table 1: Number of students by program and sex registered to the course.N-59.

The Computer Science and Organisational Technologies program blends IT expertise with business management acumen, fostering IT professionals with a broader and more nuanced skill set, including advanced soft skills. On the other hand, the Business Administration program is rooted in management fundamentals and is tailored for individuals with aspirations in managerial roles.

Initially, the FYS course offered undergraduates the opportunity to work on well defined tasks to design a prototype for one of the regional municipalities. Regional municipality management was engaged as tasks' owner, providing input and participating in the final presentation, co-evaluating the developed prototypes. The well-defined tasks were assigned to tackle mainly the prospects of developing the tourism industry in the regional county via designing a webpage or app.Within the action research, the author aims to redesign team tasks from well-defined, task-oriented challenges to ill-defined, social value problems, pursuing the achievement of the UN Sustainable Development Goals. Ethical consent was obtained from all study’s participants.

Planning the research

The planning process consisted of several stages, including negotiation with the business school dean and other two co-instructors of the course, conducting the diagnosing of the problem via qualitative research methods, designing the blueprint of the CPS course part, including selecting the method to compose the students' teams; creating the assessment tools, which served the data collection purpose, selecting, developing and adapting the learning materials to support students in their learning, communication with the municipality management team to rework the well-defined problems, aka, tasks, into ill-defined social value problems based on the development strategy of this county.

Developing materials in postdigital landscape

To develop the learning materials addressing gaps in teaching CPS skills at the business school, the author conducted diagnostic research using two qualitative methods: two focus groups with faculty members who showed interest in the research theme from the business school and questionnaires for the school Alumni members and snap of the employability readiness of the graduates with the potential employers. The focus groups, conducted via Zoom with 7 out of 27 invited faculty members teaching at the bachelor program, aimed to examine the present practice and experience with student collaboration skills, identify instances where inadequate collaboration hindered task completion, and approaches, if any, for assessing these skills within taught subjects.

The questionnaires, inspired by the works of Hesse et al. (2015), Sun et al. (2019), ATC21S, and Oliveri et al. (2017), were distributed in March-April 2023. The Alumni survey, conducted using the Phonic online platform, gathered feedback from 17 Bachelor Alumni members about their experience learning CPS skills during study time. The employer survey, distributed via LinkedIn, collected responses from 25 employers, focusing on whether the recent graduates-hirees can demonstrate and apply the CPS skill in demand and what potential gaps in the graduate's employability they identified. These findings were subsequently included in the data used to develop targeted learning materials. The course's central learning platform is Moodle, which includes a family of edtech tools used during the data collection, such as Phonic, Google Workspace: Forms, Slides, Docs, Sheets, Slido, Seesaw simulation, Video recording, Zoom conferencing, NaturalReader; Canva; Social media and etc. The on-site classes were held in the auditorium, supporting the blended learning approach, with five screens, videoconferencing, and video recording tools. The Egg Drop and Twin Tower Challenge simulations were planned to be conducted on-site using stationary materials. Pre-arrangements were made well in advance for such classes. Video and photo data were collected for the reflective assignments. The majority of teamwork was planned to take place outside of classes, allowing students to decide on the choice of collaborative tools.

Instructional design model

The learning activities were designed using the combination of 4C/ID model for teaching complex skills and professional competencies (Van Merriënboer & Kirschner, 2018), which comprises of includes learning tasks, supportive information, just-in-time information, and part-task practice and the ADDIE model (Branch, 2009) comprises five stages: analysis, design, development, implementation, and valuation, which are iterative and non-linear, suitable for simulation-based learning (Spatioti et al., 2022). The combination of two instructional design supports and creates the conditions to fully benefit from the experimental learning approach. 4C/ID model elements were to provide students the whole task experience based on authentical problems, equip with protocol, check-list and how-to-instructions.

The semester-long course consists of 14 lectures, each 4 academic hours long. Five lectures focus on developing CPS skills, with two co-instructed lectures for mid-semester and final presentations. The remaining nine lectures cover IT product development and Agile project management, guiding students in developing a tech-augmented solution prototype. Four standalone interventions are included in this thesis. The learning activities address issues identified in the developing material phase, with team composition reassessed for diversity and inclusivity. Despite organisational constraints, plans for revising the syllabus and assessment system using rubrics were made.

Data Collection

In action research, data collection should focus on evaluating the effectiveness of an intervention by identifying its successful aspects and its unsuccessful aspects rather than trying to prove its efficacy (Arnold, 2015). Continuous data collection throughout the course followed the recommended combination of self-assessment tests, situational judgement tests, and questionnaires, which allowed to answer the research questions in relation to learning activities' impact on improving the student ability to work in team and solve complex problem. The students' CPS skills self-assessment questionnaire design was inspired by the collaboration self-assessment tool created by Ofstedal & Dahlberg (2009) and the social style personality test designed by Merrill et al (1981). Both questionnaire data were collected in paper form. To compose the groups, the author used a Google Form survey to ask students to choose the primary and secondary roles in the team. The simulation usability questionnaire design was inspired by the system usability scale developed by Brooke (1996, as cited in Bangor et al., 2008) and in the literature review written by a group of researchers (Lu et al., 2022), providing a summary of a systematic review examining the methods used in usability studies of educational and learning technologies over the past two decades.

Data Analysis

To determine whether some factors of the scaffold, impact aspect of the skill or learning environment interrelate and whether individual, team and class collective results were significant, the statistical analysis, including standard deviations, correlation and T-test, was used. The author acknowledges the use of Chat GPT 3.5, 4, and 4o for assisting in brainstorming and evaluating simulation alternatives, revising learning instructions, summarising materials, and designing diagrams and tabulations. These tools helped formulate questions and scenarios, and Grammarly was used to enhance writing style and correct errors.

Results & Discussion

This chapter outlines the outcomes of four interventions from an action research initiative aimed at enhancing undergraduates' collaborative problem-solving skills through problem-based learning. Each intervention helped students tackle complex social issues and create collaborative solution prototypes. The author examined these interventions' efficacy through three research questions on scaffolding learning, assessment effectiveness, and instructional challenges.

First Intervention: Egg Drop Challenge and Collaboration self-assessment

The first intervention purpose was to test scaffold, aka, modified Egg Drop Challenge simulation (Appendix 1, part 1) and a new approach to team composition based on self-assessment of the collaboration skill, personality type test and self-enrolment to the team role of first and second choice. The total number of students registered to the course was 59. The first day for both programs' freshmen was held on-site, aka, in the school premises. The students checked in by registering their name and surname on slido_com using their smart phone by pointing the phone cameras at the QR code displayed on the 4 screens. The total number of students present for the first intervention was 56 students. The first set of supportive materials comprised of YouTube video demonstrating the Egg Drop Challenge action. Later students were able to refer to the available video and publications about different experience of designing the container to drop the egg from the height. Therefore students were definitely supported in the first task of this simulation. The second and third idea oriented tasks, aka, requirements to the parcel design were impact on environment and design for the elderly. The students were tasked to utilise the inner team knowledge and practise inquiry learning. Using the random team generator platform randomlists_com students were divided into ten groups of 5 or 6 students each. The QR code and a shortened link to the task description in the Google document format was available on the screens to scan. Prepared sets of stationary materials to design the parcel's structure from were distributed to the teams. The choice of the stationary materials were meant to put to test the environmental consciousness and age-inclusive condition to reflect the problem owner's perspective. The data in the form of measurements of the drop heights, video and photos were collected on the site. 3 out of 10 teams used psychical interactive drops from the school stairs to improve the design of the prototype, while other groups judged the structure based on their verbal discussions. Each group was tasked to record their public drops and share the video recordings with the author via WhatsApp messager for assessment purposes and production of educational materials. The author edited the simulation video to share with the students and school management (Cernavska, 2023). 6 out of 10 teams dropped their parcels from the school's 4th floor. Upon completing the public presentation - drops, each team parcel prototype was assessed for its environmentally friendly and age-appropriate design using the 10-point assessment system. The statistical analysis summary is found in the Appendix 1, part 2.

The criteria 'Age-Inclusive Design' was meant to introduce students to various aspects of the social value problem concept. Upon reviewing data in the Table 2 (Appendix 1, part 2), it becomes evident that the statistical deviation for the Age-Inclusive Design criterion reveals some interesting insights. Specifically, it indicates that students possess a slightly higher level of knowledge about the environmental impact of various materials and circular economy principles, compared to their understanding of designing products for the elderly. This is further underscored by the standard deviation of 2.0 for the age-inclusive design, which points to significant variability in how teams considered these criteria during the design and iteration process.

Upon completion the challenge, students were introduced to the author's research and explained the purpose of modified course curriculum. Students were administered two paper-based self-assessment tests to assess collaboration skills (Appendix 1, part 3) and personality type (Appendix 1, part 4). During the paper based self assessment students provided their informed consent for research participation and data collection. Written consent for the research was obtained from all registered to the course's students. The self-assessment was purposefully scheduled after the completion of the simulation, allowing students ample time to reflect on their performance as team members. Students were instructed on both tests. It appeared that there were not enough paper copies for the personality type test printed. The students without the paper copies came up with the quick solution, they took pictures of the paper based test and using the annotation filled in the questionnaire and calculated their personality type. This occurrence illustrates the postdigitalism aspect of the learning space, where the analogue, or, in the case of the research, the paper-based material, could be converted into countable one and filled in with the help of the digital tools. It has been noted that the instructions about calculating and tallying the personality type caused confusion among some students. The immediate feedback on-site helped to clarify the issue. The total number of students took part in the both tests was 56.

Closer inspection of the Table 3 in Appendix 1, part 5 shows that BITL program students claim their collaboration skill to be developed and well established is well correlated with self confidence of their peers from BBA program. The results, as depicted in the Table 3 it is notably that 5% of students from both study programs assessed their skill level as 'Emerging ', indicating room for growth. On the other hand, more than half of the course students rated their level as 'established ', suggesting a strong foundation in collaborative skills.

The results for the personality type (Appendix 1, part 5, Table 4) showed that the majority of the students perceived themselves as drivers for the task management, or followers of the expressive style practising social recognition approach in teamwork. It's difficult to assess the students self assessing skills, but the collaboration skill self-assessment could bear noticeably biases of overconfidence. Embryonic self-reflection skill is a barrier to reflect properly on the simulation experience where they practised collaboration.

To further proceed with team composition process the students were tasked to make the 1st and 2nd choice for the role they would like to take in the teams. There were 6 roles available to choose from, such as, Project Team Lead, Project Admin, Communicator & Marketing, Research Analyst, Stakeholder user experience, and Development role (technology). Students used Google Form to provide the author with input data to finish the team composition, based on the following criterion: study program, gender diversity, choice of role in the project, collaboration skill level and personality type. The business schools are ambitiously claiming to educate future leaders. The in-depth analysis of students who were first choices for the project role indicated that Project Team Lead could be of particular interest. The analysis of the dataset whose first choice was Project Team Leader was conducted can be found in Appendix 1, part 5, Table 5.

It can be seen from the data in Table 5 that there were only four students with self-assessed analytic personality types, and all four set their collaboration skill level at development. The most striking result was that only one student with an amiable personality type enrolled for the leadership role. The conducted t-test (T-test 1.156; p-value=0.277) reported no significant difference between male vs female students' skill levels within the Project Team lead role. The differences between collaboration skill levels reported t =-2.55, p-value=0.025. This p-value is less than 0.05, identified that there is a statistically significant difference in self assessed collaboration skill levels between the BBA and BITL programs for individuals in the "Project Team lead" role, suggesting that, on average, the collaboration skill level might be higher in the BITL program for this role compared to the BBA program.

The first question of this study aimed to determine how to better facilitate learning of complex CPS skills. The simulation acted as a multitask-oriented scaffold, enabling teams to successfully complete the goal of building a drop-resistant parcel. This result aligns with Ouyang et al. (2021), who found that Chinese students succeeded with clearly defined and scaffolded tasks. In contrast, ill-defined tasks posed challenges for students less familiar with collaborative learning and self-organisation. Sun et al. (2019) suggested this might be due to students' inexperience in shared understanding, creative thinking, individual accountability, and initiative. The mixed-approach simulation design requires support for both idea and task-oriented learning and strategies to overcome the "teaching to the test" culture by developing metacognition and providing feedback. The complex task design required iterations, which was a weak point for most teams. The iteration process needed full team collaboration, yet few teams benefited from testing and improving the initial prototype, possibly due to teamwork efficiency and self-organisation.

Interestingly, most students perceived themselves as skilful team players. Oliveri et al. (2017) confirmed that Y1 students' self-judgment abilities vary based on their experience and feedback. Sole reliance on self-assessment to evaluate CPS skills could lead to unreliable conclusions.

Second Intervention: Computer based simulation and perspective-taking assessment

In the second intervention, the author used the computer-based simulation 'Seesaw' to facilitate learning of the CPS sub-skills, such as, perspective taking and communication. Seesaw simulation task is to balance the seesaw with a set of prescribed weights. Students work in pair and each of them can control only either right or left side of the seesaw. The task foresaw communication and perspective giving, and taking to share the knowledge and collaboratively to answer individual questions, which differ. One student had a question on how to balance seesaw using two masses, another one how to balance with the use of three. Unless students communicate and state explicitly they are not aware about the difference in problem to solve. The computer based asynchronicity imitated real work remote environment. Pre-class homework was to play free collaborative problem solving game “Unsolved Case” on the Steam platform. Steam platform simulation was meant to prepare students for the remote setting of the in-class computer based simulation they were about to experience. To the author surprise, there were only 2 students out of 48 present in class who completed the homework. During prior held classes, the author observed variation of digital literacy skill levels among the students, which manifested itself in delegating tinkering or working with edtech tools to certain members of the team. Taking in account this observation, the author decided to set lower bar of zone of proximal development and conduct the simulation on-site in dyads, sitting face to face, partners were not allowed to see the screen of the electronic device of each other and communicate verbally. Students self enrolled for the division in pair using shared Google Doc.

Students were provided with demonstration of the simulation (Appendix 2, part 1) and instructions. Students were encouraged to use the outside class available school facilities to comfortably engage with the game. Upon completing the task, students were involved in discussion and reflection. Majority of the pairs confirmed the successful completion, however the success on the individual level varied. Then, students were tasked to complete two Google Form tests, one evaluating whether the simulation supported their learning (Appendix 2, part 2) and another self-assessing its perspective-taking skill (Appendix 2, part 3). The Seesaw simulation evaluation questionnaire contained 6 statements and one open-ended question to feedback instructor. Students used 5 points Likert scale, where 1 - very much disagree and 5 - very much agree. The total number of questionnaire’s participants varied from 47-48. The omission of making the question not mandatory was noticed during analysis. Table 6 (Appendix 2, part 2) shows the stats analysis of edtech tool evaluation results grouped by the criteria category upon coding the evaluation criterion. The standard deviation (SD) for the criteria such as helpfulness, increased understanding, provided opportunity, activity engagement, and learning task accessibility have relatively low to moderate standard deviations, ranging from 0.76 to 1.03. From these data, we can see that while there is some variation in responses, there is a notable level of agreement or consistency in how students rated the simulation on these aspects. A relatively moderate deviation implies that most participants felt similarly about the effectiveness and engagement of the simulation, though some differing opinions exist.

The data suggested that there was a consensus among the majority of students about generally simulation as an exciting learning activity. In order to assess the potential relationship between criteria, the correlation test was conducted (Appendix 2, part 5, Table 7). Of interest there is a robust positive association ($r = 0.64$) between helpfulness and provided opportunity in the simulation can be seen as a genesis of novel learning or experiential opportunities. The pronounced correlation between increased understanding and learning task accessibility ($r = 0.52$) accentuate the quintessential role of task accessibility in augmenting comprehension of perspective taking skill. What stands out is a substantial positive correlation between interest level and helpfulness ($r = 0.59$) underlining the significance of engaging content in edtech tool. The slightly negative correlation between activity engagement and interest level ($r = -0.13$) suggests that increased engagement of computer based simulation does not invariably lead to heightened interest or motivation to acquire knowledge or learn. The analysis of student feedback (Appendix 2, part 6, Table 8) on the simulation tool revealed a nuanced perspective on its effectiveness in enhancing communication and teamwork skills. As stated by one student, "The task was interesting for realising how important it is to listen and be open-minded with each other" (student 1). However, another student expressed dissatisfaction, noting that "the task seemed too easy" (student 2). The finding could be attributed to perceived too low zone of proximal development which mismatched with this particular student. Suggestions for improvement included clearer verbal instructions, as one student mentioned, "Perhaps next time please make it more clear about the task at hand verbally, because sometimes the written text can be a bit misleading" (student 3). These direct citations illustrate the diversity of opinions regarding the simulation's efficacy, emphasising the need for refinement to optimise its educational value in future implementations.

The collaborative perspective-taking assessment test (Appendix 2, part 3) was administered to students after the discussion about the simulation results, offering students an opportunity for self-reflection. The test comprised nine statements; students were asked to indicate the extent to which the statement applies to them using the self-descriptive scale: substantial, moderate, improvement opportunity and not applicable to me. The Figure 2 (Appendix 2, part 4) shows the range of skill levels for each statement. Students self-applied the general descriptive statements of the skill as solid and moderate. From the data in Table 8

(Appendix 2, part 4), it is apparent that the lowest average score is seen in Statement 5, " I frequently seek feedback from my teammates to improve our collaborative efforts" (average - 2.24) and the highest standard deviation (SD-0.76), pointing to it as an area where students might benefit from additional support. What is interesting that the correlation analysis identifies moderate positive relationships among key behaviours within team dynamics. This is rather insightful interrelationship of 0.46 between seeking feedback and supporting efforts, and the same strength of interrelation exists between seeking feedback and fostering open dialogue. This suggests that teams that prioritise openness and feedback tend to exhibit and practise open dialogue. Furthermore, the correlations of encouraging participation with supporting effort (r=0.31) and seeking feedback (r=0.37) underline the significance of diverse perspectives in enhancing team support and effort. Based on the intervention results, the simulation is widely regarded by students as an exciting educational tool, directly addressing how such activities can scaffold improvement of cognitive skills. These results align with those of Vlachopoulos and Makri (2017), Leemkuil et al. (2000), and Seng Yue Wong et al. (2022), who found that simulations and games improve soft skills like task management, teamwork, and problem-solving. The strong positive correlations 0.64 between the simulation's helpfulness and learning opportunities, and 0.52 between increased understanding and task accessibility demonstrate its effectiveness in fostering problem-solving skills in a multidisciplinary context.

Post self-assessment indicates moderate to solid skill development in perspective-taking, with a 0.59 correlation between interest level and helpfulness, highlighting the role of engaging content. This self-assessment measures the simulation's impact on key skills and identifies areas needing improvement, such as feedback mechanisms, aligning with research on teaching collaborative problem-solving skills. This result might be linked to less developed cognitive empathy, crucial for solving social value problems. The Egg Drop Challenge confirmed these findings, with teams showing weaker results in designing prototypes for elderly groups. Both the simulation and self-assessment affirmed their effectiveness in facilitating CPS skills learning.

Third Intervention: Twin Tower Challenge and Teamwork assessment

The original simulation task was modified to utilise team capacity and reinforce the concepts of constraints, team effectiveness, and adaptability (Appendix 3, part 1). The task was to build up two identical towers to support two marshmallows simultaneously. The simulation included three constraints introduced to the teams at certain time intervals, which amplified the iterative process and put to the test their team's adaptability skill. Teams were alerted on the time intervals when constraints were announced. The timer on five screens was used to help teams with time monitoring. The observation revealed that some teams needed to be faster to start collaboratively working on the task, with varying engagement levels and motivation to succeed. A few teams missed or skipped constraints announcements. At the end of task time, the author took measurements of the lowest timer out of two and validated the fulfilment of the requirements.

Six out of 10 teams qualified for the assessment, as they fulfilled the requirements of the Twin Towers challenge. Team 8 constructed the tallest twin tower of 73 cm; the qualified towers' height varied from 39 to 73 cm, making the average height 50 cm is twice as good as other business school students' achievements from the dataset shared by Tom Wujec (TED, 2010). The author took pictures of the towers to further use for the reference and design of supportive materials.

The teamwork assessment was designed in the Google Form and contained 12 statements and optional open-ended to feedback instructor. The first demographical question was to indicate team number. Students were prompted to share their personal view on their teamwork using 5 point Likert scale, where 1 (strongly disagree) to 5 (strongly agree). The results of statistical analysis found in the Appendix 3, part 2, Table 9-10 showed that the mode analysis indicate a range of consensus within teams. Teams 2 and 8 are highlighted for their strong unity in evaluations, demonstrating low variability and consistent positive perceptions across specific team functions. It is worth noting that there were differences in perceptions with Teams 3, 5, and 7 show, indicating areas of different opinions about the solutions to the test situations. Interestingly, Teams 1, 4, 6, 9, and 10 showed moderate agreement, which might have been a subject of further discussion to explore varied individual member perceptions before reaching the team decision. The overall analysis suggests that while some teams displayed consistent agreement between team members on the ranking of the solutions, others teams embraced challenges of negotiating and dealing with potential conflicting member views, emphasising the complex dynamics that could benefit from targeted improvements and create opportunity to practise learnt knowledge. There were only 9 students or less than 20% of the respondents who left feedback to the instructor, making the data to be non representative. A common view amongst feedback providers was that simulation provided students with valuable experience of teamwork and creative thinking. It is worth noticing that few students called for clearer instructions and a consideration of the activity's practical value. A possible explanation for this might that the scaffold lacked a post discussion to interrelate the insights and experience to the course learning goal. The results supports the research of Ouyang F. et al.'s (2021) that task oriented scaffolds are great contributors to the learning how structurally organise the teamwork and coordinate tasks division. However the constraints elements which introduced the elements of idea-oriented task was meant to scaffold flexibility and team self organisation to succeed with incorporating new elements into tower design. It is interesting to compare the reactions and performance of the students in both the Egg Drop and Twin Tower simulations to handle and deal with multiple simultaneous goals and constraints which represent the idea-based part of scaffolds. The results consistent with the literature that complex collaboration and self organisation require more time and support. The necessity of allotting time for the feed back to feed back could potentially enhance the metaconginition layer and improve the CPS.

Fourth Intervention: Situational Judgement test (SJT)

Teamwork is not immune to conflict and disputes caused by many reasons, including free-riding behaviour. The SJT design was inspired by insights and students' feedback from the previous iterations for the learning material development within this research. The assessment process was divided into two steps; firstly, each team member completed the test individually. Secondly, the team discussed individual results and made the collective decision on the team's choice of answers' ranking. This activity provided an opportunity to practice negotiation and decision-making in teams. Ten teams submitted their collective answers to the SJT (Appendix 4, part 1). 10 submissions were qualified to be used to assess the teams, aka, collective, answers to determine the indicative conflict resolution skill level. Table 12 (Appendix 4, part 2) below shows the team ranking of the optional answers: 1 efficient solution, 2=inefficient solution or 3= counterproductive solution. The optional answers were coded as follows: A-1, B-2, and C-3. The answers ranked equal to the conflict resolution skill proficiency level indicated in the column 'Proficiency skill level'.

The choices made by Team 4 for the solutions to the first three situations align with their proficiency level in the conflict resolution skill set. However, Teams 5, 6, and 10 only scored proficiency in one of the four situations. These results provide valuable data for individual and team reflection on skill level and negotiation dynamics. Notably, the fourth situation, which involved a conflict of interest, proved to be the most challenging for all teams. None of them succeeded in ranking the answers to the proficiency level. This presents an opportunity to review the situation scenarios for the zone of proximal development and provide additional materials on approaches to resolve conflicts of interest. Students were required to submit their answers for further analysis. 44 students submitted their individual answers to the SJT. Team 3 provided invalid answers (5 out of 44), which might be considered an opportunity to improve the quality of instructions. 39 submissions were qualified to analyse the difference between individual and team options' ranking.

The SJT results helped facilitate dynamic discussion within the group, and the self-assessment skill was practised. The mean and standard deviation scores for each intra-team answer were calculated (Appendix 4, part 3, Table 13). SD results provide insight into the amplitude of differences in the initial individual answers of the team members. The results could facilitate the analysis of the team's discussion and reflection on the decision-making process and principles, whether everyone got a voice and was listened to. The higher SD score indicates different opinions, a designed opportunity for practising active listening, negotiation and conflict resolution, which are part of the complex CPS skill set. The smaller SD observed with the fourth situation, which could be explained by potential lack of knowledge about the conflict of interest in the decision making. Whats striking that Team 1 and 7 came to the collective decision consensually, as inter-team discussions did not significantly vary in solution ranking. To assess the SJT, a one-sample T-test was conducted to determine if the mean standard deviation of team members' ranking answers for various test situations differs significantly from a hypothetical population mean of 0.5. The results showed statistically significant differences for situations 2a, 2b, 3c, and 4a, as their p-values were less than 0.05, indicating that the variability in these situations is significantly different. These results support the research of Freudenstein et al. (2018; 2020), that SJT provided opportunities for the contextualisation of the CPS skills and practising the different approaches to negotiation, dealing with disagreements and decision making. The potential area to reinforce the learning could be introduction of reflection on the statistical results and discussion the approaches each team took to arrive to the collective decision.

Conclusions

The research aimed to investigate and answer questions about pedagogical approaches for teaching complex CPS skills to undergraduates and evaluating the assessment methods used.

(R1) How can collaborative problem-solving-based learning activities scaffold undergraduate students in learning to solve a complex social value problem? The four interventions' results highlight students' active role in the postdigital environment. The ease of access to digital data presents both opportunities and challenges for CPS skill development. The influence of social media impacts perspective-taking skills and cognitive empathy, as students relied heavily on digital data, resulting in prototypes that lacked feasibility and practicality. Simulations should include both idea and task-oriented activities, using diverse materials to enhance analog and digital data recognition. The Seesaw simulation, designed for dyadic collaboration, received positive feedback, aligning with studies by Sun C. et al. (2019) and Hesse et al. (2015). Gamification in simulations can enhance motivation, encouraging students to tinker and try new approaches. Designing activities to support team self-regulation and providing feedback can improve the ability to tackle ill-defined problems.

(R2) What is the effectiveness of the different types of CPS assessments (individual self-assessment, situational judgment test, and teamwork assessment) adopted for use in the course? The Situational Judgment Test (SJT) has shown potential as a valid facilitator and assessment tool, enhancing metacognition skills. Both simulations offer valuable learning opportunities, further enhanced by scaffolds such as demonstrations and instructor feedback. The blended approach to CPS assessment has shown promise, similar to real-time feedback in sports. Assessment tools need rigorous testing to ensure validity and reliability. Educators should design SJT scenarios covering known topics and provide instructions in various media formats to meet postdigital students' expectations. These findings align with the Maker Education approach, emphasising practical applicability. However, observational assessments have significant limitations and biases, and feedback delays can hinder CPS teaching.

(R3) What specific challenges are encountered by instructors in designing and delivering learning activities for teaching CPS skills within a multidisciplinary project-based course, and how do these challenges impact students' ability to develop and apply these skills? A multidisciplinary approach supports contextualising knowledge and sense-making. Overlooking non-digital data requires additional support in structure and guidance. Ill-defined tasks demand proficient problem-solving skills and collaboration. Large group simulations require significant planning time. Introducing mentors or buddies in classes with more than five groups can provide a semi-personalised approach. Feedback on feedback can help teams practice collaboration, enhancing their ability to tackle ill-defined problems. AI assistance could be useful for basic statistical analysis, information structuring, and qualitative analysis.

Teachers in the postdigital landscape need innovative pedagogy knowledge, critical thinking, and a solid understanding of ed-tech tools. Experimental researcher-practitioners are valuable assets to educational organisations.

To conclude, teaching and assessing CPS skills require understanding the complexity of these skills within the postdigital environment, their components, and their practical relevance to students, teachers, and society. It is crucial to position CPS within the learning process of taught discipline, identify appropriate scaffolds, and assess the skills' dynamic states. Fostering critical self-examination and feedback should aim to develop the ability to self assess and mitigate biases. The education system often prioritises defined task completion, yet it must also recognise the multiplicity of data to consider for decision making and address diverse forms of continuous collaboration process, and varied tasks, aka authentic and ill-structured. This includes developing skills suitable for both Human-Human and Human-Agent collaboration through practical learning activities, allowing one to experience the wholeness of the skill set. An action research is an effective approach to enhance the ecological validity and generalisability of assessment tools.

Limitations

The research, though comprehensive, was not limited to the four interventions in this thesis. This broad scope, while beneficial, limited the depth and applicability of the findings. The study did not include two co-instructors in designing learning activities, missing valuable collaborative insights and seamless CPS integration. Inconsistent student participation challenged data collection and representation, as not all students attended classes regularly, affecting assessment validity and reliability. The digital literacy gap among students could distort findings, as varying technological competence might have influenced scaffold assessment, needing careful interpretation.

Not all interventions provided opportunities to practice all CPS skills, further limiting the findings. Large teams were struggling with motivation of each member to equally contribute. The action research aimed to modify the syllabus to address weak interconnectedness and fragmentation with other domains. However, the empirical scope needed expansion to capture these complexities fully. Some data required more in-depth statistical analysis using unavailable advanced programmes, potentially limiting conclusion validity. The author's positioning within the study introduces subjectivity, possibly influencing findings and observations, thus affecting research objectivity.

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Author's Declaration

I hereby declare that I have written this thesis independently and that all contributions of other authors and supporters have been referenced. The thesis has been written in accordance with the requirements for graduation theses of the Institute of Education of the University of Tartu and is in compliance with good academic practices.

01/06/2024

Signature Date:

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Appendices

Appendix 1, Egg Drop Challenge

Part 1: Task description

To design the prototype of the structure to securely deliver glass vials of the vaccines [Egg represents the vial of vaccine] if dropped by the drone from a height of 3 metres and higher to the vulnerable seniors in the remote flooded areas."

Team composition: 4-6 students to a group [mix teams]

Time limits: 50 minutes

Awards

- 2023 Egg Drop Challenge Winner Team - the team whose egg survives the highest drop.
- Environmental Award - the team whose solution is the most environmentally friendly (solution full life cycle - in lesser quantity materials/energy used, the output is reusable/ recyclable).

Egg Drop Champion

Age-Inclusive Design Award Winner

Environmental Impact Award Winner

- Age Equality Award - the team whose solution is well thought through taking in consideration the level of psychical and mental abilities of older persons and people with disabilities in crisis situations.

Egg Drop Supply List

Here is the list of approved materials, You do not have to use all of the materials [remember about environmental impact and target audience abilities] but you may ONLY use the materials from this list.

- 4 chicken eggs – raw NOT boiled. 3 - for iterations and 1 for presentation of your solution.
- Bubble wrap - 40 cm wide
- Commercial leaflet
- 1 toilet paper roll and 1 paper container
- Scotch Tape
- Glue - You MAY not coat your egg or glue anything

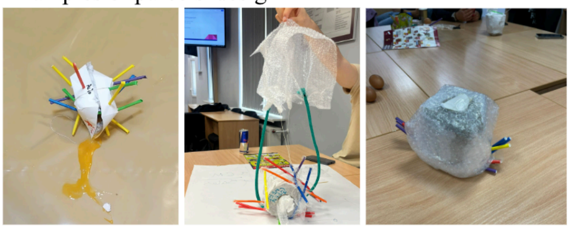
to your egg!

- Scissors
- 10 regular paper drinking straws
- 100 wooden toothpicks – regular size.
- 16 small cotton pads
- 1 metre of 2 different strings – you MAY cut up into smaller lengths
- PET film for maintaining the highest standard of cleanliness during the challenge.

You may NOT use the glue, tape, string, or anything else to strengthen your egg!! Glue, tape, string, etc. is for either holding your structure together or for packing material. You may not adhere anything to your egg.

We will be dropping the eggs from the stairs. Each Team is responsible for cleaning after itself upon completion of the assignment.

Examples of parcels' design



Outcomes and instructor's notes:

Overall, students take away strong insights into success, failure, the design process and team work. The questions below can be used to help guide discussion and reflection from each of the teams on completion of the challenge:

- What would you change next time to work more effectively as a team?
- How do you think you could have arrived to a better result?
- How do you think rapid prototyping and testing (or the lack of) advantaged/ disadvantaged your team?
- Would creating specific roles and responsibilities for team members have effected the outcome in any way?
- How did the tight deadline effect the outcome and how could you better manage time in the future?

Part 2: Challenge assessment stat analysis

	Environmental Impact	Age-Inclusive Design
Average teams' score	7	6.5
Mode	7	7
SD	1.2	2.0

Table 2: Egg Drop Challenge assessment results analysis

Part 3: Collaboration self-assessment test

Collaboration Self-Assessment Tool

Category	1	2	3	4	Explanation	SCORE
Contribution	I tend not to share ideas, information or resources.	I share ideas, information and resources upon request.	I usually share ideas, information and resources.	I freely share ideas, information, and resources.		
Motivation/ Participation	I tend not to participate or remain engaged when a project moves away from my own immediate interests.	I sometimes make an effort to participate and remain engaged when a project moves away from my own immediate interests.	I often make an effort to participate and remain engaged even when a project moves away from my own immediate interests.	I can be relied on to participate and remain engaged even when a project moves away from my own immediate interests.		
Quality of Work	My work reflects very little effort and often needs to be checked and/or redone by others to ensure quality.	My work reflects some effort but occasionally needs to be checked and/or redone by others to ensure quality.	My work reflects a strong effort. I self-monitor to improve the quality of my work.	My work reflects my best efforts. I continuously make small changes to improve the quality of my work.		
Time Management	I rarely get things done by the deadline and others often have to adjust deadlines or work responsibilities.	I tend to procrastinate, meaning others may have to adjust deadlines or work responsibilities.	I usually use time well to ensure that things are done so others do not have to adjust deadlines or work responsibilities.	I routinely use time well to ensure things are done on time.		
Team Support	I am often critical of the team or the work of fellow group members when I am in other settings.	Occasionally I am critical of the team or the work of fellow group members when I am in other settings.	I usually represent the team and the work of fellow members in a positive manner when I am in other settings.	I represent the team and the work of fellow group members in a positive manner when I am in other settings.		
Preparedness	I forget or lose materials needed to work.	I make an effort to bring or find materials needed to work, but often misplace things.	I usually bring needed materials and come ready to work.	I consistently bring needed materials and come ready to work.		
Problem Solving	I usually do not participate in group problem solving with an open mind. I either tend not to share my thoughts and ideas or I inhibit the contributions of others.	I make an effort to participate in group problem solving with an open mind. I generally share my thoughts and ideas, but I sometimes inhibit the contributions of others.	I usually participate in group problem solving with an open mind, sharing thoughts and ideas without inhibiting the contributions of others.	I consistently participate in group problem solving with an open mind, sharing thoughts and ideas without inhibiting the contributions of others.		
Team Dynamics	I do not know how to gauge my own impact on the group, and am generally unaware of team dynamics.	I occasionally know how to gauge my own impact on the group and am somewhat aware of team dynamics.	I often know how to gauge my own impact on the group and am generally aware of team dynamics.	I consistently know how to gauge my own impact on the group and am routinely aware of team dynamics.		

- I confirm that I have received sufficient information about what my participation in the present study involves. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily by the researcher. I am aware that I can ask questions and discuss any concerns with the experimenter.
- I understand that the information provided by me will be held anonymously so that it is impossible to trace this information back to me individually.
- To ensure access to the data for the wider research community, the anonymous dataset maybe archived in an online repository or send to other researchers upon request for inspection. Any data that are released would be fully anonymized so that no individual data can be identified.

Category	1	2	3	4	Explanation	SCORE
Interactions with Others	I rarely listen to, respect, acknowledge, or support the efforts of others. I allow conflict or personal differences to interfere with communication.	I sometimes listen to, respect, acknowledge and support the efforts of others, but at times allow conflict or personal differences to interfere with communication.	I usually listen to, respect, acknowledge, and support the efforts of others. I occasionally allow conflict or personal differences to interfere with communication.	I consistently listen to, respect, acknowledge, and support the efforts of others.		
Role Flexibility	I like to either lead or follow but am uncomfortable when functioning outside my perceived role.	I am uncomfortable with role flexibility, but attempt to move outside my perceived role.	I can assume both roles (leader and follower) but am more comfortable in one role than the other.	I can easily move between leader and follower, assuming either role as needed to accomplish the task.		
Reflection	I rarely engage in self-reflection after collaborative activities but tend to focus on the behavior of others.	Self-reflection occurs after collaborative activities when prompted or reminded by others.	Self-reflection usually occurs after collaborative activities, but most often when things don't go well.	I consistently use self-reflection after collaborative activities.		

Total Score:

Maximum score: 44 points

Guide to Scoring:
10-25: Collaboration skills are emerging
26-34: Collaboration skills are developing
35-44: Collaboration skills are established

Part 4: Personality type test

Social Style_Personality Test
Instructions

1. Complete the Personal Style Inventory (below).
2. Go to page 2 to tally your Personal Style Inventory.
3. Review the results indicated by the longest bar (pages 3-6):

Do you perceive it as accurate? What does it mean for you as a member of this team? Do you recognize these styles in the behavior of others?

Check the word or phrase in each set that is most like you.

1. __ Competitive 2. __ Joyful 3. __ Considerate 4. __ Harmonious	1. __ Tries new ideas 2. __ Optimistic 3. __ Wants to please 4. __ Respectful	1. __ Will power 2. __ Open-minded 3. __ Cheerful 4. __ Obliging	1. __ Daring 2. __ Expressive 3. __ Satisfied 4. __ Diplomatic
1. __ Powerful 2. __ Good mixer 3. __ Easy on others 4. __ Organized	1. __ Restless 2. __ Popular 3. __ Neighborly 4. __ Abides by rules	1. __ Unconquerable 2. __ Playful 3. __ Obedient 4. __ Fussy	1. __ Self-reliant 2. __ Fun-loving 3. __ Patient 4. __ Soft-Spoken
1. __ Bold 2. __ Charming 3. __ Loyal 4. __ Easily led	1. __ Outspoken 2. __ Companionable 3. __ Restrained 4. __ Accurate	1. __ Brave 2. __ Inspiring 3. __ Submissive 4. __ Timid	1. __ Nervy 2. __ Jovial 3. __ Even-tempered 4. __ Precise
1. __ Stubborn 2. __ Attractive 3. __ Sweet 4. __ Avoids	1. __ Decisive 2. __ Talkative 3. __ Controlled 4. __ Conventional	1. __ Positive 2. __ Trusting 3. __ Contented 4. __ Peaceful	1. __ Takes risks 2. __ Warm 3. __ Willing to help 4. __ Not extreme
1. __ Argumentative 2. __ Light-hearted 3. __ Nonchalant 4. __ Adaptable	1. __ Original 2. __ Persuasive 3. __ Gentle 4. __ Humble	1. __ Determined 2. __ Convincing 3. __ Good-natured 4. __ Cautious	1. __ Persistent 2. __ Lively 3. __ Generous 4. __ Well-disciplined
1. __ Forceful 2. __ Admirable 3. __ Kind 4. __ Non-resisting	1. __ Assertive 2. __ Confident 3. __ Sympathetic 4. __ Tolerant	1. __ Aggressive 2. __ Life-of-the-party 3. __ Easily fooled 4. __ Uncertain	1. __ Eager 2. __ High-spirited 3. __ Willing 4. __ Agreeable

—Source: David Merrill & Roger Reid, *Personal Styles and Effective Performance*

Part 5: Data Analysis of tests

Collaborative skills' level	Emerging	Developing	Established
BBA	3	16	21
BITL	0	7	9
N - number of students	3	23	30

Table 3: Cross tabulated results of the collaboration self assessment test. N-56.

Personality type/Collaboration skill level	Emerging	Developing	Established
Amiable	0	7	3
Analytic	0	4	0
Driver	1	3	9
Expressive	2	9	18
N - number of students	3	23	30

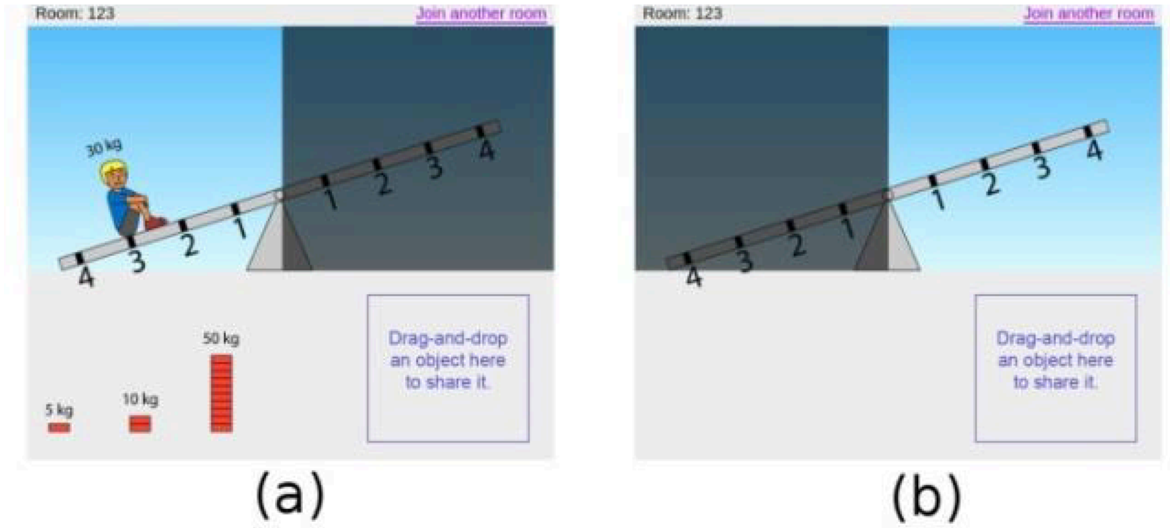
Table 4: Cross tabulated results for the collaboration self-assessment and personality type tests. N-56.

Personality type/Collaboration skill level	Emerging	Developing	Established
Amiable	0	0	1
Analytic	0	0	0
Driver	1	1	7
Expressive	1	2	6

Table 5: Cross-tabulated results for students whose first choice is Project Team Lead. N-19.

Appendix 2: Seesaw simulation

Part 1: Screenshot of simulation



Part 2: Simulation assessment questionnaire and data analysis

Please share your impressions and feedback about the computer simulation aimed at enhancing the collaborative problem-solving skills.

Please use the scale from 1 - very much disagree to 5 - very much agree

Evaluation criteria:

1. The simulation is helpful, and useful for learning to collaboratively solve the problems.
2. The simulation has increased my awareness about the skills.
3. The simulation provided opportunity to self-reflection.
4. The simulation is interesting and enjoyable.
5. The simulation activity was explained well by the instructor.
6. The learning task is acceptablly organised and well designed.
7. Open-eded question - 'You are encouraged to share your feedback with the instructor.'

Evaluation Criteria	N	Mean	SD
Helpful for Learning	48	3.60	0.68
Increased Interest	47	3.34	0.73
Opportunity to Experiment	47	3.34	0.81
Interesting and Engaging	48	3.77	0.52
Activity was Clear	48	3.60	0.57
Task is Accessible	48	3.83	0.52

Table 6: Results of the Seesaw simulation evaluation. N- 47-48

Evaluation Criteria	Helpfulness	Increased Understanding	Provided Opportunity	Interest Level	Activity Engagement	Learning Task Accessibility
Helpfulness	1.00	0.49	0.64	0.59	-0.13	0.47
Increased Understanding	0.49	1.00	0.56	0.19	0.05	0.52
Provided Opportunity	0.64	0.56	1.00	0.41	-0.02	0.45
Interest Level	0.59	0.19	0.41	1.00	-0.13	0.26
Activity Engagement	-0.13	0.05	-0.02	-0.13	1.00	0.30
Learning Task Accessibility	0.47	0.52	0.45	0.26	0.30	1.00

Table 7: Correlation analysis for the simulation evaluation criteria.

Theme Category	Key Words	Interpretation
Engagement and Ease of Use	really, thank, information, shared, easy, didnt, game, communication, bit, screen	Students appreciated the information sharing and communication aspects of the simulation, noting ease of use and game interface.
Enjoyment and Interaction	fun, time, enjoyed, screen, bit, really, easy, task, nice, thank	Students found the Seesaw simulation enjoyable, highlighting the fun and good times during task engagement.
Team Collaboration	task, helped, teammate, nice, thank, activity, didn, game, skills, easy	Focuses on teamwork and collaboration, with tasks helping participants work with teammates and develop skills.
Educational Value	task, quite, easy, interesting, teammate, information, shared, nice, thank, fun	Relates to the educational content, finding it interesting and informative, which facilitated learning and engagement.
Practical Application	way, understand, teamwork, useful, nice, skills, communication, didn, information, didnt	Highlights the practical application of the simulation, aiding in understanding teamwork and improving communication skills.

Table 8: Thematic analysis of student feedback to the instructor

Part 3: Collaborative perspective-taking skill assessment

This assessment tool is designed to help you to self-assess the mastery of the collaborative perspective taking. You will be asked to rate yourself in each of these areas. Remember the questions apply to working in a team to solve problem or run project. Consider each statement below and indicate the extent to what extend it applies to you using the scale. Select your response by checking the box, in the appropriate column.

S = Strong. This describes me all or most of the time.

M = Moderate. This describes me part or some of the time.

I = Improvement opportunity. This describes me very little or not at all.

N/A = Not applicable to me at this time

Self-Assessment statement	Statement Category (for analysis use only)
I share information with others easily	Sharing Information
I routinely listen to the opinions of team members	Listening to Opinions
I regularly acknowledge the efforts of my team members	Supporting Efforts
I consistently support the efforts of others	Reinforcing Team Contributions
I frequently seek feedback from my team members	Seeking Feedback
I encourage other team members to get involved in the discussion to share their point of views	Encouraging Participation
I seek out different views than my own during team discussion	Seeking Different Views
I ask questions to better understand what others are thinking and what are their reasonings	Asking Questions
I consistently offer the opportunity to ask questions about shared information	Fostering Open Dialogue

Part 4: Data Analysis of the assessment

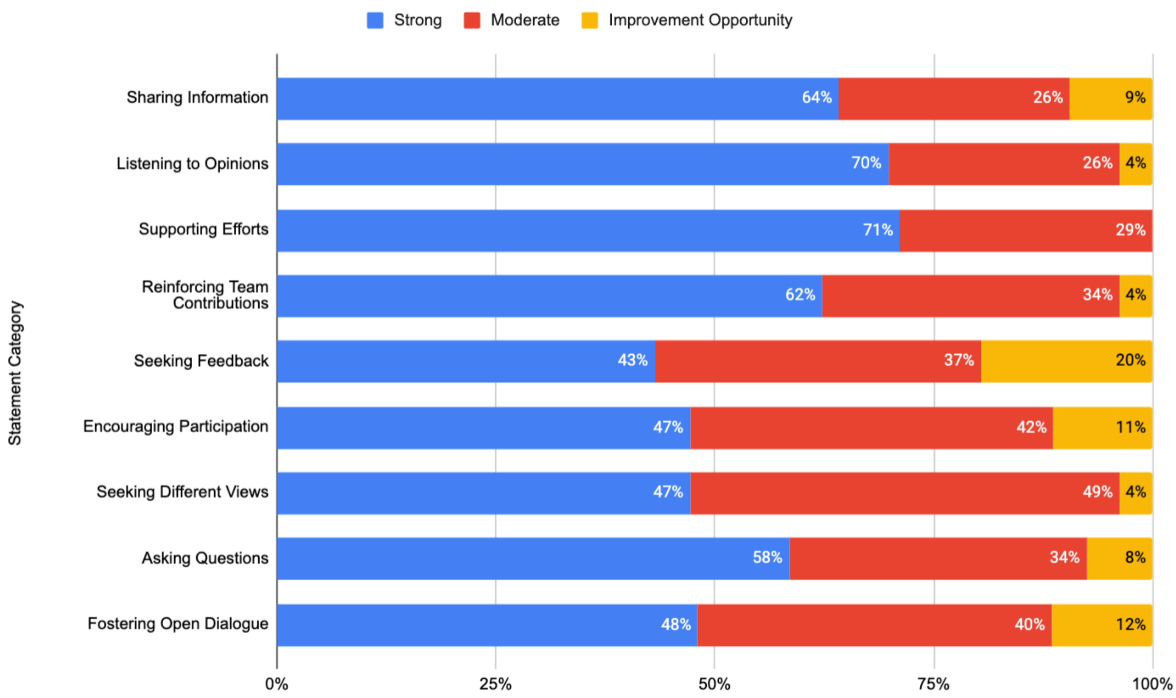


Figure 2: Results of students self assessment test of the perspective taking skills. N-47-48.

Statement	**N**	**Average**	**SD**
Sharing Information	53	2.55	0.67
Listening to Opinions	53	2.66	0.55
Supporting Efforts	52	2.71	0.46
Reinforcing Team Contributions	53	2.58	0.57
Seeking Feedback	51	2.24	0.76
Encouraging Participation	53	2.36	0.68
Seeking Different Views	53	2.43	0.57
Asking Questions	53	2.51	0.64
Fostering Open Dialogue	52	2.37	0.69

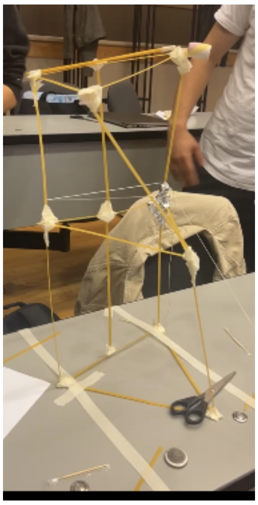
Table 8: Statistical analysis of the test results.

Appendix 3: Twin Tower Challenge

Part 1: Task description

Build two twin towers that can support two marshmallows simultaneously. But, there's a twist —there will be three constraints introduced along the way to make it more exciting and complex. There will be three constraints announced at 5 minutes, 10 minutes and 20 minutes interval. Teams are tasked to overcome the constraint.

AWARD



2023 Marshmallow Challenge Winner Team - the team whose Twin towers [identical] are the highest and successfully passed the weight test.

Task allocated time:

- Twin Towers construction - 25 minutes
- Presentation and testing - 3 minutes
- Take picture of your Twin Towers and post to Miro board.

Supply List

Here is the list of approved materials, you may ONLY use the materials from this list.

- Spaghetti Sticks
- String
- Tape
- 10 toothsticks
- 2 Marshmallow for testing

Rules: You may NOT use any paper or marshmallows to construct the towers.

- Teams are given two marshmallows at the beginning of the challenge.
- You use the marshmallow as a reference point while constructing Twin towers.
- Teams can iterate and test their designs by placing the marshmallow on top of their towers as they build. This allows them to make adjustments to improve stability and height.
- The final test involves placing the marshmallow on the completed towers to see if they can support the weight.

Post Task - Assessment of Teamwork

- Please assess your teamwork, link to assessment form: link.

Each Team is responsible for cleaning after itself upon completion of the assignment.

Part 2: Teamwork Assessment

This evaluation will help you review the way you worked within your team. As there are no 'right answers' it is important that you note your personal views, not what you think others will think or will want to hear. Please use the scale from 1 - strongly disagree to 5 - strongly agree. The anonimous results will be shared with the students. Thank you for your consideration and feedback!

Your team number:

Evaluation criterio:

1. We planned effectively
2. We clarified our objective
3. We explicitly agreed our priorities
4. We all understood our roles in this task
5. I expand others' ideas
6. I was listened to
7. I asked others to elaborate
8. I summarised the ideas of others
9. I took the lead
10. I facilitated discussion
11. We all contributed equally
12. We learnt from our mistakes

Part 2: Stat Analysis, Mode and SD.

Team Nr	Planned Effectively		Clarified Objectives		Agreed Roles and Responsibilities		Understood Roles and Responsibilities		Expanded Others' Ideas		Was Listened To	
	Mode	SD	Mode	SD	Mode	SD	Mode	SD	Mode	SD	Mode	SD
1	4	0.45	4	0.55	3	0.55	4	0.71	4	1.22	5	0.71
2	5	0.55	5	0	5	0.89	5	0	5	0.55	5	0
3	3	0.55	2	0.84	4	1.3	4	1.41	3	0.55	4	1.41
4	4	0.82	5	1	4	0.82	5	1.41	4	0.5	5	1
5	3	0.82	3	0.58	4	1.73	3	0.58	4	0.82	4	0.58
6	4	0.71	5	1.3	4	0.55	5	1.3	4	0.45	5	0.55
7	2	0.96	1	0.96	3	0.82	2	1.29	4	0.82	4	0.82
8	5	0	5	0.52	5	0.82	4	0.75	5	0.52	5	0.41
9	4	0.45	5	0.55	4	0.55	4	0.55	5	0.55	4	0.55
10	3	1.34	5	0.45	4	0.55	4	0.55	4	0.55	4	0.55

Table 9: Mode and standard deviation for Statements 1-6 N=47.

Team Nr	Developed Others' Ideas		Summarised Ideas of Others		Took The Lead		Facilitated Discussion		Contributed Equally		Learnt From Mistakes	
	Mode	SD	Mode	SD	Mode	SD	Mode	SD	Mode	SD	Mode	SD
1	4	0.89	3	1.1	3	0.89	4	0	5	0.55	5	0.55
2	5	0.55	4	0.55	4	0.55	4	0.55	5	0.45	5	0.45
3	4	0.55	4	0.89	2	0.84	3	0.84	5	1.1	3	0.84
4	5	1	3	0.96	3	0.58	4	0	5	0.5	4	1.26
5	4	0.58	3	0.58	3	0.58	4	0.5	4	0.58	4	0.58
6	4	1.22	4	0.84	3	1.22	4	0.71	4	0.84	5	0.55
7	4	0.82	4	0.82	3	0.82	4	0.82	4	0.82	5	0
8	5	0.52	5	0.41	4	0.75	5	0.41	5	0.41	5	0.52
9	5	0.55	4	0.45	3	0.84	3	0.84	4	0.84	4	0.71
10	4	0.55	4	0.45	4	0.84	4	0.84	4	0.55	5	0.55

Table 10: Mode and standard deviation for Statements 7-12 N=47.

Nr.	Evaluation Criteria	Correlation Coefficient
1	Planned Effectively	-0.68
2	Clarified Objectives	-0.27
3	Agreed Roles and Responsibilities	-0.46
4	Understood Roles and Responsibilities	-0.20
5	Expanded Others' Ideas	-0.36
6	Was Listened To	-0.14
7	Developed Others' Ideas	-0.42
8	Summarised Ideas of Others	-0.37
9	Took The Lead	0.00
10	Facilitated Discussion	-0.18
11	Contributed Equally	-0.56
12	Learnt From Mistakes	0.06

Table 12: Correlation Analysis. N=47.

Appendix 4: Situational Judgement Test

Part 1: SJT Task

Conflict resolution in a Team. *Mini case problems*

Student's name:_____________

Team Number:________

Instructions:

Make a copy of this document and save under a different name - Conflict resolution_your name. Upon completing the assignment, please, upload your individually completed Google docs file in pdf format to Moodle.

There are four situations, each with three possible options for resolution. You are requested to assess and re-order optional responses according to its effectiveness, based on your judgement. Please use Likert scale:

- 1st place - effective
- 2nd place - ineffective
- 3rd place -counter-productive

First phase

Individual [not soliciting with teammates]

Complete the test individually

Second phase

Discuss the situations with teammates, share your optional answer, discuss and agree on the team's answer.

Use the consensus approach - for an option to be chosen all team members have to support it.

Answer all test questions using this approach.

Upload your individually completed Google docs file in pdf format to Ortus.

Reflection

Discuss how you solve the disagreements?

What decision making approach did you use?

How did you make sure that each team member was listened to too?

Assignment time - 40-45 minutes

Presentations/insights sharing - 5 minutes

Situation 1: Developing a Community Outreach Program

Your team is tasked with developing a community outreach program that aims to bridge the digital divide by providing computer and internet access to underprivileged children in your local area. The goal is to enhance their educational opportunities and future prospects. However, your team is divided on whether to focus on procuring new computers or refurbishing older ones. What should the team prioritise, and how should you address this difference of opinion?

Optional answer	Your order (write 1,2 or 3)	Your team reached consensus
1. While speed is a valid consideration, we must delve deeper into the needs of the underprivileged children. Is faster necessarily better if it means a higher cost? It's essential to weigh the potential benefits and drawbacks of both options and consider factors like sustainability and long-term impact.		
2. Indeed, considering both options is a start. However, to make a well-informed decision, we need to analyse the financial implications, environmental impact, and the educational needs of the children. How do these options align with our goal of enhancing their future prospects and educational opportunities?		
3. Your suggestion to weigh the pros and cons is commendable, but it would be wise to go further by involving local schools and understanding the specific needs of the underprivileged children. In this way, we can make a decision that is not just about technology but is also grounded in the context of the local community and its educational needs.		

Situation 2: Creating a Sustainable Business Model for a Food Bank

Your team is working on a project to create a sustainable business model for a local food bank that distributes essential items to families in need. Half of your team believes that implementing an online donation platform is the key to raising funds, while the other half insists on organising local fundraising events to build community support. How would you resolve this divergence in strategies and make decisions that benefit the food bank and the community it serves?

Optional answer	Your order	Your team reached consensus
1. Combining both strategies is a good starting point. However, to develop a sustainable business model, we need to dive into details. How will we promote these online donations? What kind of local events will generate the most support? It's essential to analyse the cost-effectiveness and community engagement aspects thoroughly.		
2. Your suggestion to diversify revenue streams is sound. To refine this idea, we should delve into the specifics. What online platforms will we use for donations? What types of local events will engage the community effectively? Conducting a detailed cost-benefit analysis will help us make a more informed decision.		
3. While both options have merit, we need to delve into the specifics. How do online donations compare in terms of cost and reach to the local events? What kind of events could we organise, and how would they foster community support? A more detailed analysis is needed to make an informed decision.		

Situation 3: Procrastination and Loss of Motivation

Your team is working on a project to create an app that helps reduce food waste. One team member keeps delaying their tasks, and the project timeline is at risk. At the same time, a few team members lose motivation. How do you motivate the procrastinating team member, rekindle the enthusiasm of the disheartened members, and keep the project on track?

Optional answer	Your order	Your team reached consensus
1. "We've got to address this issue head-on. Your procrastination is affecting our progress and morale. And regarding motivation, why did you lose interest in our project?"		
2. “Look, we've got a problem. You're constantly putting things off, and it's dragging us down. And as for motivation, why have you lost enthusiasm for this project? You compromise our score!”		
3. "We can't ignore this any longer. Your procrastination is jeopardising our timeline. And when it comes to motivation, how might you make yourself stop postponing task completion? What caused your enthusiasm to die?		

Situation 4: Conflict of Interest and Leadership Disagreement

Your team is designing an eco-friendly product for a class project. One team member, who also holds the leadership position, works for a company that manufactures non-eco-friendly alternatives. They are advocating for their company's product. How do you address this conflict of interest, resolve the leadership dispute, and maintain the project's focus on sustainability?

Optional answer	Your order	Your team reached consensus
1.“We've got a problem here. You working for that company and pushing their product isn't sitting well with us. And about leadership, why should you be the one calling the shots?"		
2.“Hey, we need to talk to you about the company you work for. We're concerned that it might impact our project's goal. And regarding leadership, why do you think you should lead this project?"		
3."We've got to clear the air. Your connection to that company seems like a potential bias. And about the leadership matter, why do you think you're the best choice to lead this project?"		

Part 2: Team submitted ranking and skill level

Situation 1	Proficient skill level	1	2	3	4	5	6	7	8	9	10
1st place	3	3	3	3	3	1	1	3	1	1	2
2nd place	2	2	2	2	2	2	3	2	2	2	3
3rd place	1	1	1	1	1	3	2	1	3	3	1
Situation 2											
1st place	2	1	1	1	2	2	1	3	1	1	3
2nd place	1	3	2	2	1	3	3	2	2	3	2
3rd place	3	2	3	2	3	1	2	1	3	2	1
Situation 3											
1st place	2	1	2	2	2	1	1	1	2	2	3
2nd place	3	2	3	3	3	3	3	3	1	3	1
3rd place	1	3	1	1	1	2	2	2	3	1	2
Situation 4											
1st place	2	3	2	3	3	3	3	3	3	3	3
2nd place	3	2	1	2	1	1	2	2	2	1	1
3rd place	1	1	3	1	2	2	1	1	1	2	2

Table 12: Answers ranking on the team level

Green indicates the ranking that matches the proficiency level of conflict resolution skills and aligns with the test detriment options marked in yellow.

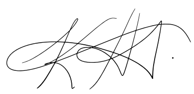
Orange indicates the proficiency skill level is only met in one out of three rankings.

White indicates a ranking that differs from the proficiency skill level answers.

Part 3: standard deviation analysis between individual and team ranking.

Team Nr	1a	1b	1c	2a	2b	2c	3a	3b	3c	4a	4b	4c
1	0.84	0.41	0.82	0.52	0.84	0.75	0.84	0.55	0.89	0.41	0.52	0.84
2	0.50	0.50	0.00	1.15	0.58	0.58	0.00	1.00	1.00	0.58	0.50	0.96
3	na	na	na	na	na	na	na	na	na	na	na	na
4	0.45	0.71	0.45	0.55	0.55	0.00	0.00	0.89	0.89	0.00	0.00	0.00
5	0.89	0.55	1.00	0.45	1.10	1.00	0.45	0.00	0.45	0.00	0.45	0.45
6	0.58	1.00	0.58	0.58	0.58	1.00	1.00	0.58	0.58	0.58	1.15	0.58
7	0	0.50	0.50	0.50	0.58	0.58	0.00	0.58	0.58	0.00	0.50	0.50
8	0.58	0.58	1.15	0.96	0.96	0.82	0.96	0.50	0.58	0.00	0.50	0.50
9	1.10	0.45	1.00	0.89	0.89	0.71	0.55	1.00	0.89	0.00	0.55	0.55
10	0.50	1.15	0.96	1.15	0.58	0.58	1.00	0.82	0.58	0.58	0.00	0.58

Table 13: SD scores for the intra team dispersion of individual decisions on options ranking



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