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An appropriate double blended learning environment based on the 4C/ID model to develop design thinking mindset

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A R T I C L E I N F O

Keywords:
Design thinking
Task-centered learning
4C/ID model
Double blended learning

A B S T R A C T

Purpose: Double blended learning is a unique and novel integration of teaching and learning contexts described in the 4C/ID paradigm. However, this issue still needs more investigation. The research compares the two levels of integration within the task in the 4C/ID model, i.e., the integration of a face-to-face classroom environment with a real work environment and the integration of a face-to-face classroom environment with a simulated environment, to develop students' design thinking and learning outcomes. The design thinking mindset allows learners to develop different levels of cognitive processes, including thinking skills, research skills, learning skills, self-exploration, creativity, and innovation. It also aids them to get set for the labor market and society.
Method: This research employed a pre-test, post-test experiment with a control group. The research subjects were selected from students of the educational sciences at Ferdowsi University of Mashhad, Iran. A total of 48 students were selected as a sample using convenience sampling, 24 of whom were randomly allocated to the experimental group and 24 were placed in the control group.
Results: Statistical analysis (ANCOVA and MANCOVA) showed that being in the real work environment improved learning outcomes and developed a design-thinking mindset compared to the simulated environment.
Conclusions: Acquiring the competency of a design thinking mindset is a complex learning process. Based on the results of this study, it can be said that presence in the real environment improves learning outcomes and the development of design thinking in educational programs for students of educational sciences.

The social environment and labor markets are facing a variety of new and complicated difficulties and requirements as a result of the 21st century's fast-changing trends (Tsai et al., 2023). The policies and pressures of the labor market and society to prepare people for the changing world have highlighted the importance of soft skills and employability as the goals of investing in higher education (Healy, 2023). Universities are now required to develop students' professional abilities comprising a wide variety of complicated skills

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to fit them into their future careers (Chernikova et al., 2020). A complex skill refers to a skill or ability that requires a high level of knowledge, practice, and often involves multiple steps or components. In addition, a skill that is complex has both recurring and non-recurring aspects (Van Merrienboer et al., 2024).

To find a common language between higher education and the labor market, the scope of soft and complex skills needs to be limited to a manageable concept such as design thinking (Denning-Smith, 2020). Design thinking is a model of thinking that equips people with tools to effectively face the growing needs and challenges of today's world and complex social issues (Li et al., 2019; Liu & Li, 2023; Vignoli et al., 2023). Therefore, this type of skill needs to be developed in students.

Developed these types of complex learning can be supported using holistic design models that emphasize authentic learning tasks (Van Merrienboer & Sweller, 2010). One of the holistic models is the four-component instructional design model (4C/ID), which includes four components of learning tasks: supportive information, procedural information, and part-task practice (Costa et al., 2021). In any educational model, regardless of its components and elements, it is possible to use a variety of methods, including on-the-job training methods such as internships, face-to-face classroom training methods, and online or offline electronic learning methods. Sometimes these methods are presented separately, and sometimes they are an integration of face-to-face classrooms with asynchronous or simultaneous e-learning (Kim et al., 2008). In 4C/ID, a special and new type of combining of learning and training environments is presented as "double-blended learning", where two levels of blends are proposed, such that the first blend is the combining of face-to-face classroom training with online training. The second blend relates to the combination of working on learning tasks in both a simulated setting and in a real task environment (action arena) (Van Merrienboer et al., 2024).

Since the 4C/ID model focuses on the development of complex skills (Chernikova et al., 2020) and the role of the simulated environment in fostering thinking has been established (Hanshaw & Dickerson, 2020; Rico et al., 2023); specifically this study compares two levels of the blend within the task class in the 4C/ID model: the integration of a face-to-face class environment with the authentic work environment and the integration of a face-to-face class environment with the simulated environment. The impetus for this study is the necessity of students' presence in authentic environments to apply the theoretical knowledge learned in classroom settings to real-world scenarios. Such presence helps students improve their practical skills and adaptability to the work environment (Suetos, 2023). Additionally, it aids in the development of a design-thinking mindset and strengthens employability skills, particularly design thinking. Since there isn't any research to develop the design thinking mindset, especially by using holistic design models; this study hopes to while achieving the optimal integration of learning environments based on the 4C/ID model, develop design thinking mindset and provide new insight into the 4C/ID model for higher education.

1. Literature review

1.1. Design thinking

The term "design thinking" originated by John Christopher Jones in the 1960S and originally referred to the thinking behind designed products (Luka, 2014). Then Brown expanded the concept of design thinking and called it a discipline that leads to solving complex problems in creative and innovative ways (Brown, 2008). Over time, it has evolved to include various interpretations, including process, method, tool, way of thinking, or way of working (Cross, 1982; Dorst, 2011; Kimbell & Street, 2009; Lawson, 2006). While Design Thinking was initially associated with design and architecture (Dorst, 2011; Hews et al., 2023), it has expanded to other industries and disciplines and that has been used for innovation and creating value in various fields including business, law, primary school education, science, medicine technology, government services among others (Hews et al., 2023; Pande & Bharathi, 2020).

Design thinking is a mindset (Luka, 2014; Thi-Huyen, Xuan-Lam & Thanh Tu, 2021) and a human-centered approach to learning, collaboration, and problem-solving (Brown, 2008). It allows learners to develop different levels of cognitive processes, including thinking skills, research skills, social competence, learning skills, self-exploration, creativity and innovation (Dell'Era et al., 2020; Lorusso et al., 2021; Tsai, 2021). Design thinking has been defined in different sources as a process and way of thinking to solve complex and wicked problems in the real environment (Akpınar et al., 2016; Gottlieb et al., 2017). Design thinking was proposed as a solution-based skill or approach used by experienced designers to creatively address complex problems that are ill-defined or unknown (Razzouk & Shute, 2012; Thi-Huyen, Xuan-Lam & Tu, 2021; Wolcott et al., 2021). Therefore, it is thought that design thinking can be used to solve "difficult" and "wicked" problems, that is, problems that are difficult or impossible to solve due to incomplete, variable, and incompatible requirements that are generally hard to identify. So, because they are difficult to solve, they are called malicious or evil (Goldman & Zielezinski, 2021).

In addition, design thinking is considered an analytical and creative process (Akpınar et al., 2016; Razzouk & Shute, 2012), an approach to creative problem-solving (von Thienen et al., 2018), an approach to support and develop innovation (Oliveira et al., 2021), dynamic capability (Liedtka, 2018), tools for the development of innovative products, services, and processes (Gruber et al., 2015), learning strategy (Aija, 2018), effective tool of education (Faregh & Amirkhizi, 2024), a combination of research-based human-centeredness and educational innovation (Lee, 2018), mentality, methods, and working tools in the world of education (Luthfi & Wardani, 2019), a method, orientation or perspective for designing and designing learning, reflecting the complex processes of research, and learning (Dym et al., 2005), the thinking model that every learner needs (Li et al., 2019). Design thinking as a mindset, methodology and work tool has given a new color to the world of education.

Experts believe that design thinking is becoming more important in education because it is a way of thinking that can be applied to almost any field (Tschimmel et al., 2017). Due to the connection between design thinking and business innovation, design thinking has become a key concept in contemporary education (Dam & Teo, 2024; Koh et al., 2015; Lor, 2017). Therefore, many countries are investing in education that integrates design thinking processes, skills, and mindsets across the curriculum, bridging academia and the professions (Koh et al., 2015). It is now taught at leading universities around the world. In the higher education environment, design thinking is used to create integrated learning experiences for students (Welsh & Dehler, 2012), to improve problem-solving skills in the 21st century (Razzouk & Shute, 2012), stimulating students for ideation and creativity (Lugmayr, 2011), needs assessment, designing and developing medical education curriculum (Gottlieb et al., 2017), developing critical reasoning and interpersonal skills in students (Glen et al., 2015), producing innovative and publishable educational materials (Sheehan et al., 2018), rethinking Project Management Education (Ewin et al., 2017), etc. The results of a meta-analysis based on 25 articles showed that design thinking has a positive effect on students' learning (Yu et al., 2024).

As well as, research has shown that skills such as problem-solving (McLaughlin et al., 2022), teamwork, critical thinking, empathy, flexibility, and communication are the main components of the design thinking process (Denning-Smith, 2020). The lack of agreement on what constitutes design thinking complicates its development (Razzouk & Shute, 2012). Due to the complexity of the concept of design thinking, efforts have been made to identify the characteristics of people who have or display design thinking. Such characteristics can be presented using different terms such as traits (Blizzard et al., 2015), mentality, and mindset (Dosi et al., 2018). However, the term "mindset" seems to be the most appropriate (Brenner et al., 2016), as it refers to "the set of ideas, beliefs, and behaviors that characterize an individual" (Paparo et al., 2017).

In their study on university lecturers who are known as e-learning champions, Gachago and his associates (2017), identified their common tendencies, which include cooperation, empathy with the learner, and problem orientation, and stated that these common tendencies are the same as "design thinking mindset" in the literature. Design thinking experts at the Stanford University School of Design call this mindset a set of "vital attitudes for the design thinker" (Both & Baggereor, 2010). According to Hassi and Laakso (2011), this way of thinking "describes the tendency towards the work in progress and the mindset based on which problems are dealt with".

Elements such as "experimental and exploratory," "ambiguity tolerance and risk-taking" are described as "optimistic" and "futuristic". Schwartz and his colleagues also identified 11 characteristics of a "design thinking mindset," which are empathy towards people's needs, being equipped to cooperate and welcome diversity, being curious and receptive to new perspectives and learning, paying attention to the process and modes of thinking, experimental intelligence, intentional and obvious action, conscious creativity, acceptance of uncertainty and risk-taking, modeling behavior, desire and willingness to make a difference and critical questioning (Schweitzer et al., 2016). Regardless of the terms used, it seems that a design-thinking mindset is a multifaceted concept.

This type of thinking has been an integral part of the fields of design, engineering, and business and has also had a positive impact on 21st-century education because it involves creative thinking in problem-solving (Razzouk & Shute, 2012). The design thinking mindset shows the framework of the design thinking process and is defined by open-mindedness, willingness to collaborate in disciplines, user-centeredness, experimentality, as well as inductive, deductive, and creative reasoning, etc. (Redlich & Lattemann, 2019).

According to social psychology literature, design thinking mindset can be separated into cognitive (thinking), behavioral (doing), and affective (feeling) components (Schweitzer et al., 2016). AIGA (American Institute of Graphic Arts) offers a "Head, Heart and Hands" approach that is a holistic perspective. It integrates the intellectual, emotional, and practical aspects of the creative process. "Head" symbolizes the intellectual (knowledge) component. The team focuses on strategic thinking, problem-solving and the cognitive aspects of design. It involves research and analytical thinking to ensure that design decisions are purposeful. "Heart" represents the emotional (attitude) dimension. It emphasizes empathy, passion, and human-centeredness. This aspect is crucial to understanding the users' needs, desires, and experiences to ensure that designs resonate on a deeper, more personal level. "Hand" signifies the practical execution of ideas (skill), the craftsmanship, and the skills necessary to turn concepts into tangible solutions. This includes the mastery of tools, techniques, and materials, as well as the ability to implement and execute design ideas effectively (Ixdf., 2016).

As seen, the conceptual foundations of the design thinking mindset have several components in the three dimensions of knowledge, skill, and attitude, which are necessary to understand for researchers' studies. Accordingly, this type of complex learning requires the use of specific instructional design models such as the 4C/ID model. The 4C/ID is well associated with the components of design thinking because it emphasizes the development of complex skills or professional competencies, enhances the transfer of education to new positions including the workplace, and develop 21st-century skills (Van Merrienboer, 2019).

1.2. 4C/ID model

Since the 1990s, experts have shifted from goal-based instructional design techniques to task-based approaches to better address the acquisition of complex cognitive skills and professional competencies (Frerejean et al., 2019). The most effective forms of education are those that focus on complex skills and give students practical, real-world experiences that call for the integration and coordination of information, abilities, and attitudes (Francom & Gardner, 2014; Merrill, 2002; Van Merrienboer et al., 2024). The more elements that a skill entails and the more interactions between them, the more complex the skill (Van Merrienboer et al., 2024). According to Merrill (2002), contemporary instructional design approaches, learning is driven by genuine and rich learning challenges. To better relate the learning environment to the work environment and build essential abilities, task-based methods center learning around full real-world (i.e., authentic) problems or professional tasks (Brown et al., 1989), to provide a way to better connect the learning environment to the work environment and develop the necessary skills (Frerejean et al., 2019). Well-designed learning tasks encourage learners to integrate and coordinate the required skills, knowledge and attitudes. This ultimately results in rich knowledge that can be transferred to daily life and future work situations (Van Merrienboer et al., 2003). Examples of task-based models are Cognitive Apprenticeship (Brown et al., 1989), Developmental Theory (Reigeluth, 1999), Basic Principles of Education (Merrill, 2002), and the 4C/ID Model (Van Merrienboer, 1997). The task-based teaching strategy is specifically designed to teach complex skills (Rosenberg-Kima, 2012). Developing design thinking is a complex skill, as it requires extensive knowledge of problem-solving, critical thinking, communication etc. It also requires multiple skills, such as teamwork and empathy. A professional, critical, flexible, and creative attitude is necessary to transfer learning from an educational environment to a real-world environment. Therefore, education through a task-oriented approach is a good fit for developing the design thinking mindset.

The 4C/ID model is one of the task-oriented models that were developed by Van Merrienboer (1997) as a model for complex learning or a whole-task. Since then, this model has been increasingly used in face-to-face and online learning environments (Costa et al., 2021). The 4C/ID model which focuses on complex skills or professional competencies, increases the possibility of transferring learning from the education environment to a new environment, such as the work environment and development of 21st-century skills, and is well in line with current educational trends (Van Merrienboer, 2019). The 4C/ID model's premise is to integrate knowledge, skills, and attitudes. This model includes four components of learning tasks: supportive information, procedural information, and part-task practice (Costa et al., 2021). Fig. 1 shows the schematic view of this 4C/ID model.

The main component, or rather, the backbone of this model, is learning tasks that are based on authentic situations that people encounter in practice. The purpose of providing the learning task is to transfer learned competencies to a real environment (Van Merrienboer et al., 2024). Learning tasks have both recurrent and nonrecurrent aspects. Recurrent aspects are also called 'routine' to indicate that they are routinely performed by learners after completion of the training program; they involve the application of rules or procedures. While nonrecurrent aspects, also known as non-routine, are actions that are relatively new to learners, require effort, and have a specific outcome. They always involve problem-solving, reasoning, or decision-making (Van Merrienboer, 2019; Van Merrienboer et al., 2024; Vandewaetere et al., 2014).

Learning tasks that have a similar level of complexity and required knowledge are grouped into task classes. Learning tasks within a particular task class is always equivalent because they can be performed using the same body of knowledge. Each new task class tries to raise the knowledge, skills, and attitudes of learners to a higher level (Van Merrienboer et al., 2024). Although the tasks within a task class are similar in terms of complexity, they differ from each other in many other aspects, such as the variety of actions within each task class and the reduction of the amount of supportive information from the first to the last task within each task class (Vandewaetere et al., 2014). Thus, the training program's learning tasks should be representative of the diverse tasks in the real world (Van Merrienboer et al., 2024). Learners usually complete these tasks in a simulated or real-world environment. Many learning tasks can be simulations, from paper-based case studies to role-playing, or immersive training with simulation mannequins, as well as real-life professional tasks (Frerejean et al., 2023).

Supporting information is the second component that describes how to deal with tasks and how to organize the territory (Van Merrienboer & Dolmans, 2015; Van Merrienboer et al., 2003), which helps learners in nonrecurrent aspects. This information is connected to all learning tasks in a task class and can be accessed by learners anytime they want. In the next task class, supporting information complements the previously presented information and enables learners to do things they were unable to do before (Van

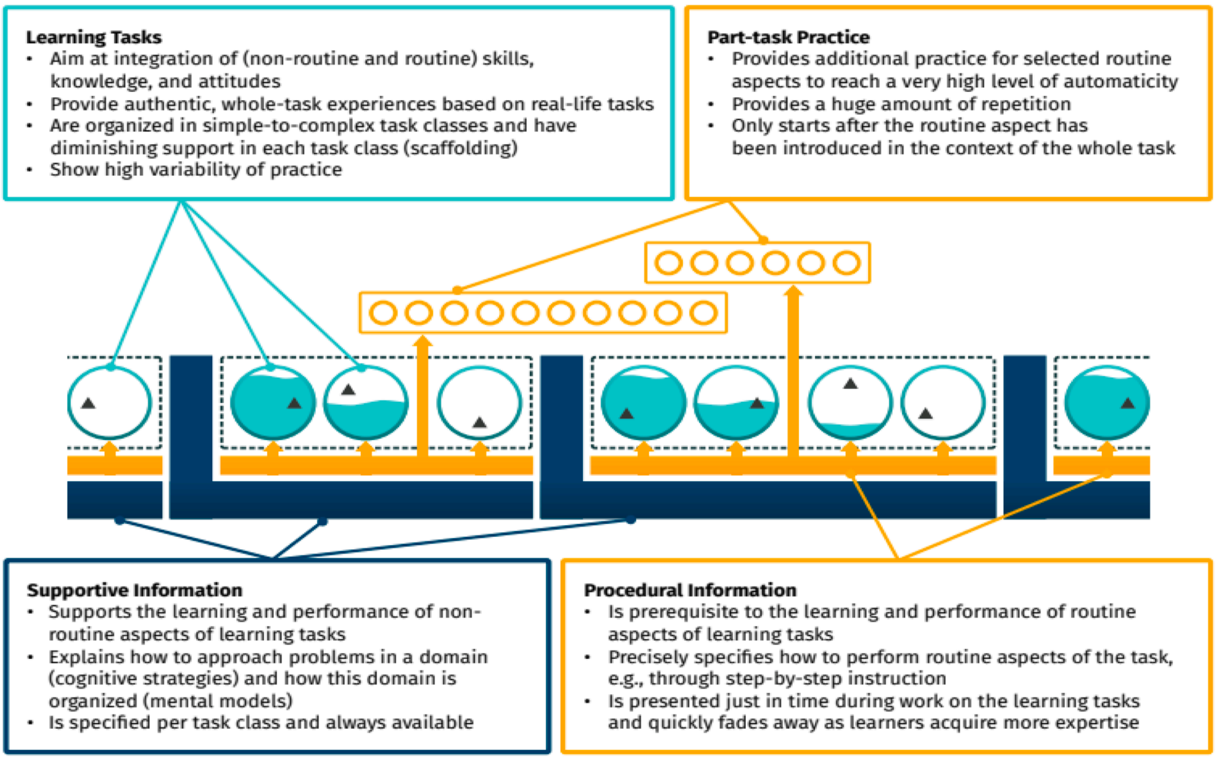

Fig. 1. Schematic view of 4C/ID model (Van Merrienboer, 2019).

Merrienboer et al., 2024). These supporting information as resources provide cognitive strategies and mental models that learners will need to complete their learning tasks (similar to the theory that is taught). This supportive information provides a bridge between what learners already know and their work on learning tasks (Van Merrienboer et al., 2002). Lectures, workshops, demonstrations, observations, readings, podcasts, e-learning modules, and AR or VR content are all ways to present this information. Learners read these materials before or during the whole work training (Frerejean et al., 2023).

The 4C/ID model's third component is procedural information. This is provided in time during learning tasks describing step-by-step procedures for performing recurrent aspects of tasks, which are always carried out in the same way (Van Merrienboer & Dolmans, 2015; Van Merrienboer et al., 2003). The best time to provide procedural information is just before completing the task, and then it decreases and disappears for the next learning task; this reason, it is also called timely information (Van Merrienboer et al., 2024). Instructors can offer feedback or materials that contain how-to instructions, including job aids, reference cards, manuals, or checklists (Frerejean et al., 2023). Part-task Practice is the last component of the 4C/ID model, which is an opportunity to practice recurrent aspects and achieve automaticity (Van Merrienboer & Dolmans, 2015; Van Merrienboer et al., 2003). This is only necessary when the learning tasks do not provide the required amount of practice. A highly integrated knowledge base can be achieved by combining part-task practice with learning tasks. To facilitate automation, procedural information specifies exactly how to perform the recurrent aspects of learning tasks and part-task practice provides additional repetition for to-be-automated recurrent aspects that need to be developed up to a very high level of automaticity (Van Merrienboer et al., 2024). These three components (supporting information, procedural information, and part -task practice) are logically associated with learning tasks in a way that best supports the development of complex skills (Van Merrienboer, 2019).

As stated the 4C/ID model focuses on transferring learning naturally and dealing with real-life tasks and emphasizes the development of problem-solving, reasoning, and decision-making skills. Tasks need innovation and creativity (Van Merrienboer et al., 2024). In addition, learning tasks often require teamwork and interprofessional work, providing good opportunities to practice communication, collaboration, interpersonal and intercultural skills (Claramita & Susilo, 2014; Susilo et al., 2013), which are considered the characteristics of "design thinking mindset." So, the 4C/ID model provides great opportunities to develop thinking skills (Van Merrienboer et al., 2024), including design thinking mindset in learners.

1.3. Double blended learning

As stated in the introduction, in any educational model, regardless of its components and elements, it is possible to use a variety of educational methods. Research evidence in professional education suggests that mixed methods can bridge the gap between theory and practice (Rowe et al., 2012; Terry et al., 2018). This type of training also provides the possibility of teaching an integrated learning experience (Maxwell, 2016); therefore, blended learning can foster target competencies such as a design thinking mindset better than face-to-face or electronic methods (Vallee et al., 2020).

The 4C/ID model encourages using various inductive and comparative methods to develop competencies. Also, educational programs that use the 4C/ID model usually use a wide range of both traditional and new online media. In this model, to achieve the optimal integration of methods, a special and new type of integration called double integration is presented. In terms of the 4C/ID approach, this means that in the first integration, supportive information is provided online, but work on learning tasks is face-to-face, and the second integration is an integration of working on learning tasks in a simulated environment and a real work environment (Van Merrienboer et al., 2024). This integration provides the possibility of using the advantages of all three inductive and comparative methods (Lage & Platt, 2000; Van Merrienboer et al., 2024). The integration of real and simulated learning environments adds another dimension to the learning experience of learners (MaseBen & Nel, 2020).

The type of simulation depends on the learning context (Chernikova et al., 2020). Simulation provides the possibility to replace and enhance real-life events to achieve educational objectives through guided experiences and experiential learning in a safe way without endangering organizational resources. Specific learning outcomes, learning needs, and instructional levels should determine which simulation methods are appropriate (Hill et al., 2023). In this research, simulation means the use of case studies. Many educational programs designed with the 4C/ID model have blended this reciprocal learning model (Van Boeijen, 2019; Vandewaetere et al., 2014), but how to combine these methods during the learning process needs to be investigated.

This study to compare blended of a classroom and simulated training versus classroom training and the workplace (of low fidelity) based on the 4C/ID model to answer these research questions: For student group who combining of the classroom environment and the real work environment based on the 4C/ID model within the task class and another student group who combining of the classroom environment and the simulated environment, is there a more significant effect between their on:

1. Improving student learning outcomes?
2. Developing of design thinking mindset?

2. Method

2.1. Design and participants

This research used a pre-test-post-test experimental plan with a control group to compare the classroom environment of the face-to-face classroom, the real work environment and the simulated environment in the 4C/ID learning environment to develop the competency of design thinking mindset and learning outcomes of students.

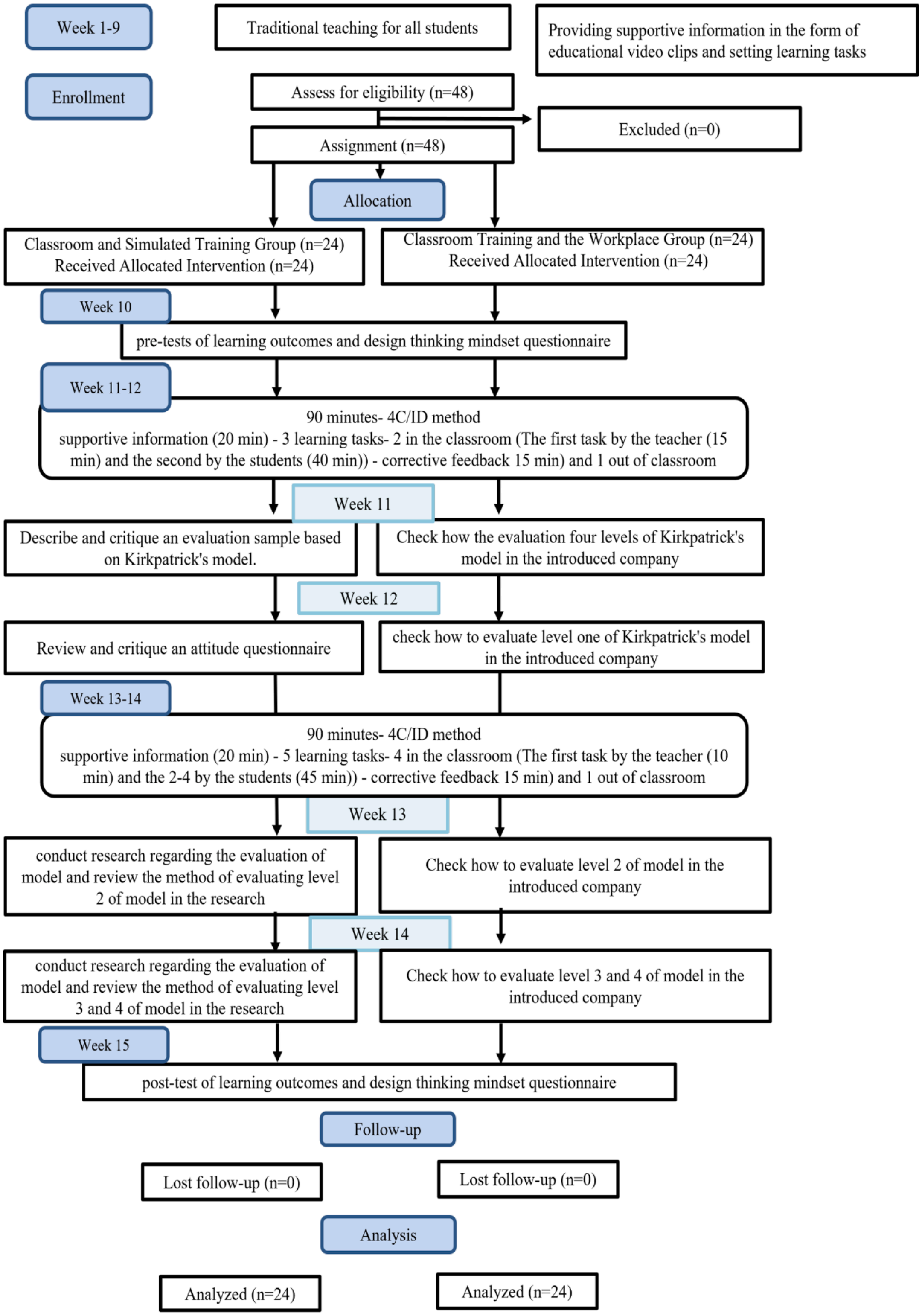

Fig. 2. CONSORT flowchart.

The research population included educational science students studying in the Faculty of Educational Sciences and Psychology of Ferdowsi University of Mashhad, Iran. The participants in this research were 48 educational science, who were randomly placed in a control ($n = 24$) and an experimental group ($n = 24$). A total of 14 women (58.3 %), and 10 men (41.7 %) were included in the experimental group while 12 women (50.0 %) and 12 men (50.0 %) were placed in the control group.

2.2. Data collection procedure

The educational evaluation course was selected for this research. This course is offered in the second semester of the academic year 1401–1402, from February to July 2023, and in 16 sessions lasting 90 min. It is divided into two parts: from the first session to the midterm exam and after the midterm exam. The researchers selected four sessions from the second part, which is dedicated to Kirkpatrick's 4-level educational evaluation model and covered the months of May to July. Kirkpatrick's evaluation model was chosen for two main reasons: First, it is a topic that involves the integration of different skills such as interpretation, analysis, and design of different evaluation steps (complex skills). Second, this issue would raise the possibility of universal presence in the real work environment, i.e., organizations and industries. The researchers designed and implemented it based on the 4C/ID model. The first part of the course was taught in the traditional way. The intervention process is illustrated in Fig. 2.

The classroom in which the two groups were trained was the same. Only to better adjust the educational program, the time of the class was different in the two groups. One group was trained on Saturdays and the other group was trained on Mondays. The researcher chose a relatively large class with the possibility of arranging the chairs in a circle to do the learning tasks in groups. In addition, the class was equipped with audio and video facilities for playing supportive information. Table 1 presents a sample of the steps required to design a training course for complex learning tasks.

At the start of each session, as supportive information, an educational clip related to the subject of that session was played for about 20 min. The rest of the class was dedicated to doing homework, as shown in Table 2.

As outlined in the literature review, design thinking encompasses elements such as problem-solving, creativity, and empathy. To effectively develop this mode of thinking and its associated components during each session, students were assigned a task class. The learning tasks within each task category were diverse and were arranged from simple to complex. As shown in Fig. 2, in both groups, a comparative approach was used to present the task; that is, the teacher gave both groups specified tasks based on Kirkpatrick's model. The students were given at least one to three tasks related to the lesson's subject in each session, and they had to complete them in the classroom. There were three tasks given in the first and second sessions. Two tasks were done in the classroom: the first task was done by the teacher and the second task was done by the student and a task was completed by the student outside of the classroom. There were five tasks given in the third and fourth sessions. Four tasks were done in the classroom: the first task was done by the teacher, the second to the fourth task was done by the student, and a task was completed outside of the classroom. After doing each task, the teacher provided corrective feedback as procedural information. To increase empathy and foster teamwork students did some tasks in groups. Both the control and experimental groups had the same tasks. At the end of each session, students were given tasks to complete outside of the classroom. This task was different between the experimental and control groups. So, the experimental group performed the task in the real environment while the control group performed the task in the simulated environment. During each session, the amount of guidance gradually decreased, as shown in Fig. 3. Therefore, the students did not receive any guidance for the last task they completed.

Table 1
Intervention research implementation stages.

Stage	Procedure	Implementation
Design	Selecting an educational topic.	Choosing the topic to introduce Kirkpatrick's educational evaluation model, goals, and general principles.
	Designing the learning environment based on a 4C/ID model.	Determining the main goals and referring to the 4 levels of Kirkpatrick's model.
	Designing instructional course.	Providing supportive information in the form of educational video clips and setting learning tasks
Implementation	Randomly placing participants in two experimental and control groups.	Experimental group: randomly placing students in groups of 5 and asking them to do homework in a real work environment (including the electricity department, fire department, and Mashhad city train). Control group: requiring this group to perform tasks in a simulated work environment.
	Administrating pre-tests.	Implementation of learning outcomes test and design thinking mindset questionnaire in experimental and control groups before the course starts.
	Implementation of the training course based on the 4C/ID model by the teacher and completion of the task (intervention).	Informing students about this educational model. Providing supportive information before the start of the classroom in the form of a video clip and presenting the relevant tasks. Explaining the details of the lesson, and answering questions and ambiguities by the teacher in the classroom. The presence of the experimental groups in the real work environment and control groups in a simulated environment to do tasks.
	Administering the post-test.	Implementation of learning outcomes test and design thinking mindset questionnaire in experimental and control groups at the end of the course.
Analysis of effectiveness	Variable: Design thinking mindset. Variable: learning outcomes test.	Design thinking mindset questionnaire (Dosi et al., 2018) in pre-test and post-test. Researcher-made tests in pre-test and post-test.

Table 2
The process of education.

Session	Supportive information	Classroom	Out-of-class tasks
First: Model introduction	Based on the topic of each session, an educational clip was prepared using voiced slides by the research team. In these educational clips was explained the main questions answered by each level of the model, the reasons for its importance, important guidelines regarding how to evaluate and necessary explanations for each level were presented. These clips were played at the beginning of the class in the presence of the teacher in both groups.	Kirkpatrick's model, including its history and brief introduction of all 4 levels, reactions, learning, behavior, and results, was described. The purpose of each level of the model, the topic, the tools used, and the application of each level were described by the teacher. The first task was completed by the teacher, and then the second task was done by the students in the classroom.	• The control group was assigned to describe and critique an evaluation sample based on Kirkpatrick's model. • The experimental groups were sent to the introduced company to check how the evaluation was done in each of the four levels of Kirkpatrick's model. The evaluation was guided by the following questions?! ■ When was the evaluation done? ■ What tools did they use to evaluate? ■ Who did the evaluation?
Second: reaction level		Given that a questionnaire is the primary instrument used to assess response level, during this session, a questionnaire was presented, and reviewed, and explanations were provided on the development of the attitude questionnaire as well as potential errors. The job was then completed by the professor and the students as described in the first session.	• The control group was assigned to review and critique an attitude questionnaire. • The experimental group was sent to the company to check how to evaluate level one of Kirkpatrick's model in this company.
Third: learning level		While completing the topics related to the level of learning, the following topics were given to the students to explain how to evaluate the level of learning for them based on the supportive information and the teacher's explanations. Excel software training course for company employees. Teaching the task-based method to newly hired teachers. Defining the role of parents and teachers' associations for teachers.	The control group was assigned to conduct research regarding the evaluation of Kirkpatrick's model and review the method of evaluating level two of this model in the research. • The experimental group was sent to the company to check how to evaluate level 2 of Kirkpatrick's model in this company.
Fourth: levels of behavior and results		While completing the topics related to the level of learning, the following subjects were given to the students to explain to them how to evaluate the two levels of behavior and the results based on the supportive information and the teacher's explanations. 1. Flipped classroom course for university professors. 2. Network security training course for employees of a company. 3. Student life skills course for undergraduate students.	The control group was requested to seek research regarding the evaluation of Patrick's model and review the evaluation method of levels 3 and 4 of this model in the conducted research. • The experimental group was sent to the company and checks how to evaluate levels 3 and 4 of Kirkpatrick's model in this company.

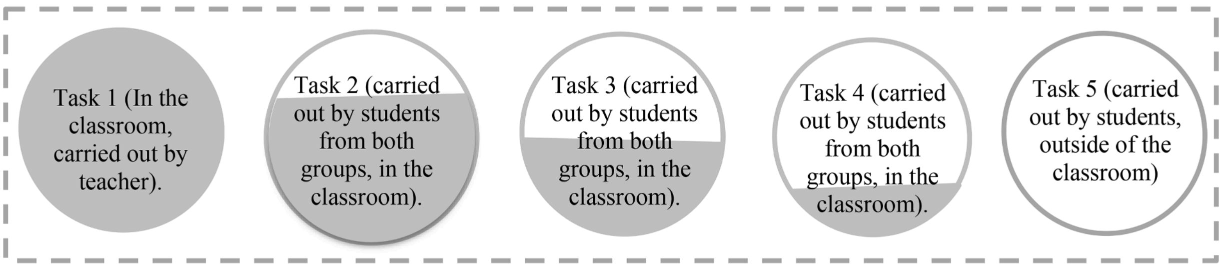

Fig. 3. Task classes presented in each class session.

As shown in Fig. 3, in an educational program, each task class begins with one or more learning tasks with a high level of support and guidance (indicated by gray circles), continuing with learning tasks with a lower level of support and guidance and ending with conventional tasks without support and guidance, indicated by filled circles (Van Merrienboer & Kester, 2008).

2.3. Instruments

2.3.1. Design thinking mindset questionnaire

A questionnaire design (Dosi et al., 2018) (Appendix 1) was used to measure thinking mindset. This questionnaire contains 70 items with 19 components. Items are five-choice (from completely agree to completely disagree) on a Likert scale. After receiving the developer's permission of the design thinking mindset questionnaire, this tool was translated based on the Brislin model using the back translation method (Brislin, 1970). Then, the translated questionnaire was presented to 300 students. Reproducibility (stability) was evaluated using the intracluster correlation coefficient. The internal consistency was evaluated using Cronbach's alpha. Content validity was assessed through confirmatory factor analysis by 11 experts in educational sciences and design thinking and reliability of this questionnaire using the test-retest method by Vaqari and his colleagues (2023) in the Iranian context. The results of confirmatory factor analysis (CFA) confirmed the structure of eight factors (risk tolerance, human-centeredness, holistic view, problem reframing, teamwork, experiment, adductive thinking, and creative self-confidence) with 38 questions. Cronbach's alpha coefficient for the overall scale (0.925) and the correlation between test and retest responses for the entire instrument ($ICC = 0.842$) were obtained at a significance level of $p < 0.001$, which indicates the repeatability and good consistency of the instrument. The reliability of the design thinking mindset evaluation questionnaire in this research was calculated with a Cronbach's alpha coefficient of 0.87 in the pre-test and 0.92 in the post-test, which shows the very good reliability of the questionnaire.

2.4. Learning outcomes survey

Two researcher-made tests were used to evaluate students' learning outcomes. The pre-test included 18 questions and the post-test included 28 test questions. Both tests were aligned with Kirkpatrick's educational evaluation model and designed with the help of the course teacher based on the suggestions in the book "Evaluating Training Programs: The Four Levels," written by Donald Kirkpatrick, and measure students' knowledge, principles, concepts, and skills. The content validity of the tests was confirmed by two educational evaluation specialists and also with the help of the content target table. The pre-test and post-test questions were also similar for both groups.

2.5. Data analysis

Descriptive statistics (frequency, mean, and standard deviation) were used for each group to analyze the research data. Univariate analysis of covariance (ANCOVA) was performed to compare the performance of groups in post-test learning outcomes. Since the design thinking mindset has 8 components, multivariate analysis of covariance (MANCOVA) was used to analyze their associated data. All statistical operations were performed using SPSS version 22 software.

3. Results

This research was an attempt to compare the combination of classroom and simulated training versus classroom training and the workplace (of low fidelity) based on the 4C/ID model. Table 3 shows descriptive data such as means, standard deviation, and research components according to the type of test (pre-test, post-test).

To investigate the effect of real work environment and simulated work environment on students' learning outcomes, univariate covariance analysis was used. In both groups, the differences between the pre-test and post-test scores were normally distributed, as shown by the Kolmogorov-Smirnov test (control group $p = 0.200$; experimental group $p = 0.111$). The results of Levine's test for the homogeneity of variances in the dependent variable revealed that the variance did not differ significantly between the two groups ($p = 0.136$). Interactions of the covariate and the independent variables (homogeneity of regression slopes) were examined ($p = 0.346$). Since the assumptions were not violated, parametric statistics were used and, ANCOVA.

This analysis was used to compare the means of the groups in the post-tests of the learning outcomes in the real work environment

Table 3
Mean and standard deviation of variables in the control and experimental group.

Variables and components	Experimental group				Control group			
	Pretest		Posttest		Pretest		Posttest	
	M	SD	M	SD	M	SD	M	SD
Embracing risk	18.67	2.014	22.96	2.74	18.37	2.28	20.92	2.46
Human centeredness	17.58	1.32	22.71	2.01	18.12	1.36	19.63	1.13
A holistic view	8.79	1.25	11.67	1.49	10.79	1.64	11.75	1.19
Problem reframing	9.83	1.17	12.75	1.67	9.75	1.07	11.00	1.44
Team working	14.63	2.32	17.67	2.10	14.67	1.46	15.50	2.39
Experimentation	16.79	1.50	20.29	2.01	16.63	1.99	18.33	2.19
Abductive thinking	13.58	1.74	16.75	1.54	14.67	1.95	16.25	1.71
Creative confidence	23.83	1.46	29.54	1.38	24.75	2.36	26.29	2.27
Design thinking mindset	124.79	6.36	153.96	7.13	127.37	9.56	139.33	9.49
Learning outcomes	6.77	1.80	18.43	1.28	6.80	1.81	15.77	1.89

groups ($M = 18.43; SD = 1.28$) and the simulated work environment group ($M = 15.77; SD = 1.89$) while controlling the effects of the pre-tests. Table 4 shows the ANCOVA results of the comparison of the CBPGT effect on the learning outcomes. Based on Table 4, data analysis at the 99 % confidence level showed a significant difference between the experimental and control groups. The result of ANCOVA ($F\ (1,44) = 5.624,\ p < 0.01$) showed a significant difference between the groups, in such a way that the experimental group had better learning results than the control group in the post-test. Also, the value (*Adjusted R Squared* $= 0.74$) shows that 74 % of changes in the dependent variable, i.e. the increase in learning scores, are due to the intervention. Therefore, the presence in the real work environment leads to improved learning outcomes compared to the simulated environment.

To compare the real work environment and the simulated environment on developing design thinking mindset competence of multivariate covariance analysis were used. The presumptions using the Kolmogorov-Smirnov test (normality), Levene's test (equality of variances), and interactions of the covariate and the independent variables (homogeneity of regression slopes) were examined. In both groups, the differences between the pre-test and post-test scores were normally distributed, as shown by the Kolmogorov-Smirnov test (control group: $p = 0.151$; experimental group: $p = 0.200$). The results of Levine's test for the homogeneity of variances in the components of dependent variable revealed that the variance did not differ significantly between the two groups ($p > 0.01$). Interactions of the covariate and the independent variables (homogeneity of regression slopes) were examined ($p > 0.01$). Since the assumptions were not violated and the homogeneity of variances and covariances did not differ significantly between the groups, and minimum sample size ($n \geq 30$) scientifically considered acceptable for conducting the parametric test, statistical test of (MANCOVA) were used. Table 5 shows the MANCOVA results of compare the real work environment and the simulated environment on developing design thinking mindset competence.

The result of Wilks's lambda ($F = 11.535,\ p < 0.05$) showed the significance of the multivariate test index at the 95% confidence level. There was a significant difference between the experimental and control groups in at least one of the components of the design thinking mindset. Based on Table 5, there is a significant difference between the intervention and the control groups in terms of Human centeredness ($F(1,\ 26) = 23.543,\ p \leq 0.05$), Problem reframing ($F(1,\ 26) = 13.825,\ p \leq 0.05$), Team Working ($F(1,\ 26) = 10.069,\ p \leq 0.05$), Experimentation ($F(1,\ 26) = 9.626,\ p \leq 0.05$), Adductive Thinking ($F(1,\ 26) = 4.662,\ p \leq 0.05$), Creative confidence ($F(1,\ 26) = 30.592,\ p \leq 0.05$). Based on these results, the experimental group performed better than the control group in the post-test on the mentioned components of the design thinking mindset.

As a result, at the 95 % confidence level, the real work environment had a significant effect on the design thinking mindset. The difference between the scores of the experimental and control groups or the size of the influence factor of presence in the real work environment was also ($\eta = 0.78$). This means that 0.78 % of the variance of the remaining scores is affected by being in the real environment.

4. Discussion

Higher education institutions are under a lot of pressure to update their curricula to promote both technical competency and employability skills in light of the digital era. Furthermore, businesses are continuously searching for graduates with soft skills including problem-solving, creativity, analytical thinking, time management, motivation, and communication in addition to the necessary academic credentials (Aliu & Aigbavboa, 2023). Design thinking is a concept that can encompass soft skills. However, the development of soft skills, or, in general, design thinking and employability, is not at the core of the curriculum. The reason is that it has been defined as the development of weak general or "soft" skills in a way that is not related to the main learning area of a discipline (Bennett, 2018) it is, therefore, necessary to consider these types of skills that prepare a person for life in the real environment and the labor market. For this purpose, education needs to be linked with real life. One way to strengthen the relationship between the educational environment and real life to develop competencies is to use learning tasks based on professional tasks, (Van Merrienboer et al., 2024) using holistic models such as 4C/ID (Frerejean et al., 2021; Hosseinzadeh et al., 2023; Maddens et al., 2020; Marcellis et al., 2018; Miranda, 2015; Postma & White, 2015; Sarfo & Elen, 2007a, 2007b; Susilo, van Merrienboer et al., 2013); double-blended learning (Van Merrienboer, 2023). In addition to these hybrid approaches, in which digital learning is combined with face-to-face learning and school learning is combined with workplace learning, there are more promising approaches for learning in the digital age (Van Merrienboer, 2016). The review of the research background shows that no study compares the integration of the classroom environment and the real work environment to the integration of the classroom environment and the simulated environment, and this is the first research that has been conducted with this purpose based on the 4C/ID model.

However, simulation in higher education allows learners to use real problems and also creates a learning environment to practice and facilitate the acquisition of complex target skills (Chernikova et al., 2020). The results of this study show a greater effect of being present in the real work environment compared to the simulated environment. Using the 4C/ID model led to an increase in the mean scores of both variables of design thinking mindset and learning outcomes compared to the pre-test in both the control and

Table 4
The results of ANCOVA comparing the real work environment and the simulated environment learning outcomes.

Source	Sum of squares	df	Mean squares	F	*p*-value	Effect size
Group	14.474	1	14.474	5.624	.022	.113
pre-test	3.551	1	3.551	1.380	.246	.030
Error	113.250	44	2.574			
Total	14,237.813	48				

Table 5
The results of MANCOVA comparing the real work environment and the simulated environment on developing design thinking mindset competency.

Source	Dependent variable	Sum of squares	df	Mean square	F	*p*-value	Effect size
Group	Embracing risk	20.423	1	20.423	4.045	.052	.099
	Human centeredness	61.956	1	61.956	23.543	.000	.389
	A holistic view	5.828	1	5.828	3.456	.071	.085
	Problem reframing	26.268	1	26.268	13.825	.001	.272
	Team working	36.718	1	36.718	10.069	.003	.214
	Experimentation	35.504	1	35.504	9.626	.004	.206
	Abductive thinking	11.567	1	11.567	4.662	.037	.112
	Creative confidence	68.568	1	68.568	30.592	.000	.453
	Design thinking mindset	1820.001	1	1820.001	46.439	.000	.557
Error	Embracing risk	186.801	37	5.049			
	Human centeredness	97.372	37	2.632			
	A holistic view	62.388	37	1.686			
	Problem reframing	70.302	37	1.900			
	Team working	134.929	37	3.647			
	Experimentation	136.470	37	3.688			
	Abductive thinking	91.805	37	2.481			
	Creative confidence	82.932	37	2.241			
	Design thinking mindset	1450.060	37	39.191			
Total	Embracing risk	23,463.000	48				
	Human centeredness	21,742.000	48				
	A holistic view	6664.000	48				
	Problem reframing	6918.000	48				
	Team working	13,490.000	48				
	Experimentation	18,151.000	48				
	Abductive thinking	12,812.000	48				
	Creative confidence	37,698.000	48				
	Design thinking mindset	1,038,051.000	48				

experimental groups, i.e., the group trained through a low-fidelity simulator and trained through the real environment. The effectiveness of the 4C/ID model has been investigated in various studies, and these results research are in line with the findings of previous studies (Frerejean et al., 2021; Hosseinzadeh et al., 2023; Maddens et al., 2020; Marcellis et al., 2018; Miranda, 2015; Postma & White, 2015; Sarfo & Elen, 2007a, 2007b; Susilo, van Merrienboer et al., 2013).

The analysis of the findings indicates that the student's presence in the real work environment, or, in other words, the integration of the classroom environment and the real work environment, can improve learning compared to the simulated environment. These results are in agreement with the findings of (MaseBen & Nel, 2020), which showed that in real learning environments, learners have the opportunity to do different things. As a result, this environment provides preparation for real-world situations and improves students' learning experiences. Work-integrated learning enables learners to experience their future work environment and develop general skills that positively affect their employability (Smith & Gibson, 2016; Winborg & Hägg, 2023). There is significant evidence that presence in the real work environment has a positive effect on employment outcomes, such as increasing work readiness and professional socialization (Jackson, 2015) and improving academic achievements and learning outcomes (Johnson & Stage., 2018).

The analysis of the findings indicates that the student's presence in the real work environment, or, in other words, the integration of the classroom environment and the real work environment, leads to the development of a design-thinking mindset. Design thinking mindset has eight components, including "embracing risk" (includes "risking failure and failing fast" and the inclination to take risks in terms of process (energy, time, …) for deep exploration of the context and new solutions, however crazy/foolish/mad and unconventional) (Dosi et al., 2018), "human-centeredness" (focusing "on understanding human behaviors, needs, and values" (Howard & Davis, 2011), a way to solve "complex and strategic problems" (Howard et al., 2015)), "a holistic view" (the ability to consider the whole problem, taking into account various factors like "socioeconomic patterns, relationships, dependencies" (Koria et al., 2011), "including technical feasibility, organizational constraints, regulatory implications, competitive forces, resource availability, Strategic Implications as well as the Costs and Benefits of Different Solutions Proposals" (Schweitzer et al., 2016)), "problem reframing" (reformulating "the initial problem" in a "meaningful and holistic way, taking all the findings, and discovering the right interpretation), "teamwork", experimentation" (trying things out in an iterative way, and moving between divergent and convergent ways of thinking) (Dosi et al., 2018), "abductive thinking" (the ability of "building conclusions from incomplete information, making small leaps into a partially known future" (Collins, 2013) and "moving from what is "known'' to the exploration of alternative solutions"), and "creative confidence" (one's own trust in his creative problem-solving abilities) (Dosi et al., 2018). In line with the results of the current research, the results (Smith & Gibson, 2016; Winborg & Hägg, 2023) showed that being in a real work environment is effective in developing team skills, problem-solving skills, and self-confidence to deal with students' uncertainty. Also, according to Nguyen et al. (2019), being in a real environment leads to an increase in soft skills, the development of theoretical and practical knowledge, and solving real problems. There is little opportunity to compare the results of this study with those of other studies since there haven't been many investigations comparing the real workplace and the simulated one. Yet, studies on the impact of the simulated environment compared to the classroom setting have occasionally shown improvements in learning outcomes and traits like self-efficacy in the simulated environment compared to the classroom setting (Cahoon et al., 2011). Additionally, the results of several studies show that while in-person training is still required, virtual reality-based simulation may either supplement or replace in-person training (Ke et al., 2021). A training program cannot be based entirely on simulations. Rather, a well-designed program often includes full-task practice in simulated situations and the work environment (Frerejean et al., 2023). In addition, the use of simulations of any kind, including high-fidelity and low-fidelity simulations such as role-playing in a training scenario, is useful for enhancing learning, developing skills such as critical thinking, and preparing students for internships and real life (Hill et al., 2023; Watson et al., 2021).

4.1. Limitations and future studies

The current study has some limitations. First of all, although the sample size in this study was appropriate for the research question, a larger sample size could strengthen the validity and reliability. Future studies could consider expanding the experiment to include more cities and countries. Because this study comes from a course in the curriculum, it would be helpful to apply it to other courses to investigate the effect of dubbel blended learning in different fields. Second, the fact that participants in this research are undergraduate students. Therefore, it is suggested this research be conducted on a range of students at different levels of education.

Third, the education duration is in total about 90 min in 4 sessions, and we didn't examine the long term effects of the education. Future research may consider extending the education to a longer one (e.g., one semester of the academic year or an academic year) to increase the possibility of integration of different skills.

Since, participants were available to us for one academic semester. So, test-retest reliability for academic achievement was not possible. test was not possible in a short period of time.

5. Conclusion

The 4C/ID model indicates that to reach the real environment, one must move from classroom training to training in a simulator environment and from there to the workplace. However, it seems that based on the results of this study, given the nature of the humanities and a social science, training in a simulator environment is not necessary and the learner can be transferred directly from the classroom environment to the real workplace. The use of simulators, especially high-fidelity simulators, i.e., simulated environments based on virtual reality, in training where there is a possibility of danger, emergency preparedness, and complex decision-making, such as the training of health care workers, including doctors in various specialized areas, nurses, and to learn negotiation and conflict resolution, Technical training and the training of abstract concepts that may be difficult for learners to fully understand are more applicable, such as for aviation industry workers. As a result, a real environment leads the students of social sciences and humanities, including educational sciences, to improve learning results and the development of soft skills. Training in the real workplace provides hands-on experience and hands-on skills, while simulation training allows for controlled practice and risk-free learning. The effectiveness of each of these methods depends on the specific goals and requirements of the training program. According to the results of this study, it can be said that presence in the real environment improves learning and the development of design thinking in the educational programs of educational science students.

CRediT authorship contribution statement

Zahra Vaqari Zamharir: Writing – original draft, Validation, Investigation, Formal analysis, Data curation. **Morteza Karami:** Writing – review & editing, Supervision, Project administration, Methodology, Conceptualization. **Jamshid Jamali:** Writing – review & editing, Validation, Methodology. **Mahmoud Saeidi Rezvani:** Writing – review & editing, Supervision.

Appendices

Appendix 1. Design thinking mindset questionnaire

Item	Strongly agree	Agree	Have no opinion	Disagree	Strongly disagree
I prefer new contexts rather than familiar ones.					
I like taking many chances, also if it leads me to make mistakes.					
I am able to understand which are the impacts on the external environment of the solution we are proposing.					
I am comfortable in dealing with unsolved problems.					
I am comfortable in taking risks.					
I think it is important to reframe the initial problem in order to achieve a good result.					
I am comfortable in dealing with unsolved problems.					
I actively involve users in diverse phases of the design process.					
I enjoy the fact that a solution can result from unexpected directions.					
I am comfortable to insert into the final solution factors coming from a broader vision.					
People are source of inspiration while identifying the direction of the design solution.					
I generally seek as much information as I can in new situations.					

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(*continued*)

Item	Strongly agree	Agree	Have no opinion	Disagree	Strongly disagree
I am comfortable to work with people having diverse perspectives and abilities from mine.					
I look for something new in a new situation.					
I am able to consider what I am doing from a broader perspective.					
I am comfortable to develop new knowledge with other team mates.					
I believe in my abilities to creatively solve a problem.					
I am capable to reframe the initial problem statement.					
I am comfortable to see problems from the users point of view.					
I am comfortable to try new approaches to solve problems.					
I am comfortable to experiment.					
I am comfortable to make prototypes in order to explore.					
I am capable to discuss mistakes and learn from them.					
I am comfortable to receive feedbacks and learn from them.					
I desire to create value with the final solution.					
I am comfortable to think something new, different from what already exists.					
I am comfortable to put myself into the shoes of user.					
I am comfortable to invent new conditions for future possibility of the project.					
I am comfortable to use prototypes to represent new ideas.					
I think I can use my creativity to efficiently solve even complicated problems.					
I am comfortable to share my knowledge with my team mates.					
I have the desire to change the status quo.					
I think I can overcome difficulties.					
I am comfortable to positively think and act.					
I can tune into how users feel rapidly and intuitively.					
I am comfortable working with people from outside of my organization.					
I am comfortable transforming hypothesis in something to be tested.					
I am comfortable change my view to problem statement.					

Appendix 2. Standardized factor loading values in the final model to assess construct validity and Cronbach's alpha coefficient of dimension design thinking mindset questionnaire

Factor loading	**item**	**Dimension**	**Number of items**	**Cronbach alpha**
0.424	q1	D1 embracing risk	6	0.695
0.533	q2			
0.482	q4			
0.531	q5			
0.654	q9			
0.499	q12			
0.462	q11	D2 human-centered	6	0.677
0.406	q15			
0.512	q23			
0.580	q29			
0.620	q33			
0.525	q44			
0.539	q3	D3 holistic view	3	0.666
0.473	q13			
0.641	q19			
0.446	q7	D4 problem framing	3	0.658
0.585	q22			
0.424	q47			
0.476	q17	D5 teamwork	4	0.627
0.554	q20			
0.591	q39			
0.596	q45			
0.602	q25	D6 experiment	5	0.698
0.572	q26			
0.667	q27			
0.492	q28			
0.499	q46			
0.444	q16	D7 abductive thinking	4	0.602
0.520	q18			
0.643	q34			
0.494	q36			
0.623	q21	D8 creative self-confidence	7	0.752
0.604	q30			

(*continued on next page*)

(*continued*)

Factor loading	item	Dimension	Number of items	Cronbach alpha
0.436	q32			
0.586	q37			
0.480	q40			
0.552	q42			
0.565	q43			
		Total	38	0.925

Data availability

Data will be made available on request.

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