ICOPEV 2022

5TH INTERNATIONAL CONFERENCE
ON PRODUCTION ECONOMICS
AND PROJECT EVALUATION

CONFERENCE PROCEEDINGS BOOK

29 – 30 SEPTEMBER 2022

POLYTECHNIC INSTITUTE
OF CASTELO BRANCO,
CASTELO BRANCO, PORTUGAL

ICOPEV 2022

5TH INTERNATIONAL CONFERENCE ON PRODUCTION ECONOMICS AND PROJECT EVALUATION

CONFERENCE PROCEEDINGS BOOK

29 – 30 SEPTEMBER 2022

POLYTECHNIC INSTITUTE OF CASTELO BRANCO,
CASTELO BRANCO, PORTUGAL

Media Partner:

co-financiado por:

EDITORS

Luís Farinha
Madalena Araújo

Constança Rigueiro
Daniel Raposo
João Neves
Ofélia Anjos
Rogério Dionísio

Title: Proceedings of the 5th International Conference on Production Economics and Project Evaluation.

Publisher: Polytechnic Institute of Castelo Branco and University of Minho

Publisher address:
Av. Pedro Álvares Cabral, nº 12, 6000-084 Castelo Branco, Portugal

Depósito Legal: 510815/23

ISBN: 978-989-53931-5-2

DOI: www.doi.org/10.53681/2023.l03/03

Design: Rethink Research Group | Rita Cruz Tavares

Design Managment:
Rogério Ribeiro
Daniel Raposo
João Neves

Typesetting: Rita Cruz Tavares
Luís Ascenção
Maria Félix
Soraia Rodrigues

Produção e Impressão:
DC Print Lab, IPCB

SCOPE AND OBJECTIVES

The Project Evaluation and Selection are recognized as an Interdisciplinary Field requiring Engineering, Economic, Business, Design and Project Management expertise Skills. Projects compete for scarce resources and choosing the best allocation of these resources is a complex and challenging task that decision makers face every day. Methodologies and techniques must be defined and implemented, aiming to support the decision-making process according to the goal of each organization. As society changes, the goals change too. It is now evident that complex decision making cannot be based only on financial criteria. From the private company point of view, aspects like the strategic dimension of projects, or its alignment with the company's strategy, the contribution to long term objectives or employees' wellbeing must not be overlooked. The same way, the economic perspective of the project underlines the need to properly consider and include in the analysis the social and environmental dimensions of the projects as decision variables. The main goal of the Conference ICOPEV2022 is to join together academics and professionals from a variety of fields with interest on the issues of production economics, engineering project and innovation management, entrepreneurship, decision making and business intelligence applications.

HISTORY OF THE ICOPEV

ICOPEV 2022 – 5th International Conference on Production Economics and Project Evaluation.
29 – 30 September 2022, Instituto Politécnico de Castelo Branco, Castelo Branco, Portugal.

ICOPE 2018 – 4th International Conference on Production Economics and Project Evaluation.
20 – 21 September 2018, University of Minho, Guimarães, Portugal.

ICOPEV 2016 – 3rd International Conference on Project Evaluation,
16 – 17 June 2016, University of Minho, Guimarães, Portugal.

ICOPEV 2014 – 2nd International Conference on Project Evaluation
26 – 27 June 2014, University of Minho, Guimarães, Portugal.

ICOPEV 2011 – 1st International Conference on Project Economic Evaluation
28 – 29 April 2011, University of Minho, Guimarães, Portugal.

CONFERENCE TOPICS

- Business Intelligence;
- Innovation & Technology;
- Project Management;
- Knowledge & Technology Transfer;
- Energy Issues;
- Decision support Systems;
- Cost Management;
- Sustainability;
- Innovation & Entrepreneurship.

PROCEEDINGS REVIEWERS

Ana Paula Silva
Polytechnic Institute of Castelo Branco, Portugal

Ângela Oliveira
Polytechnic Institute of Castelo Branco, Portugal

Ana Vaz Ferreira
Polytechnic Institute of Castelo Branco, Portugal

Wellington Alves
Universidade do Minho Centro ALGORITMI, Portugal

Ana Vaz Ferreira
Polytechnic Institute of Castelo Branco, Portugal

Arlindo Silva
Polytechnic Institute of Castelo Branco, Portugal

Carlos Lozano-Moncada
Escuela de Ingeniera Eléctrica y Electrónica, Universidad del Valle, Cali-Colombia

Carla Ferreira
University of Minho, Department of Production and Systems, Portugal

Carlos Cambra

Cláudio Barradas
Polytechnic Institute of Santarém, Portugal

Constança Rigueiro
Polytechnic Institute of Castelo Branco, Portugal

Daniel Ferreira de Azevedo
Polytechnic Institute of Viseu, PT

Daniel Raposo
Polytechnic Institute of Castelo Branco, Portugal

Domingos Santos
Polytechnic Institute of Castelo Branco, Portugal

Fernando Reinaldo
Polytechnic Institute of Castelo Branco, Portugal

Fernando Romero
University of Minho, Department of Production and Systems, Portugal

Filipa Vieira
University of Minho, Department of Production and Systems, Portugal

Filipe Fidalgo
Polytechnic Institute of Castelo Branco, Portugal

Isabel Soares
Faculty of Economics of Porto, University of Porto, Portugal

João Neves
Polytechnic Institute of Castelo Branco, Portugal

Jorge Cunha
University of Minho, Department of Production and Systems, Portugal

Jose Donizetti de Lima
Universidade Tecnológica Federal do Paraná, Brasil

José Manuel Hernández-Mogollón
Universidad de Estremadura, Spain

José Metrôlho
Polytechnic Institute of Castelo Branco, Portugal

Luís Farinha
Polytechnic Institute of Castelo Branco, Portugal

Madalena Araújo
University of Minho, Department of Production and Systems, Portugal

Manuel Lopes Nunes
University of Minho, Department of Production and Systems, Portugal

Ofélia Anjos
Polytechnic Institute of Castelo Branco, Portugal

Osvaldo Santos
Polytechnic Institute of Castelo Branco, Portugal

Paula Ferreira
University of Minho, Department of Production and Systems, Portugal

Paulo Afonso
University of Minho, Department of Production and Systems, Portugal

Paulo Silveira
Polytechnic Institute of Castelo Branco, Portugal

Pedro Nuno Mor Silva
Polytechnic Institute of Castelo Branco, Portugal

Pedro Torres
Polytechnic Institute of Castelo Branco, Portugal

Rita Cruz Tavares
Rethink Research Group, Portugal

Rogério Dionísio
Polytechnic Institute of Castelo Branco, Portugal

Rui Pedro Juliano
Polytechnic Institute of Castelo Branco, Portugal

ICOPEV 2022 CONFERENCE CHAIRS

Madalena Araújo
(ICOPEV)
University of Minho, Department of Production and Systems, Portugal

Luís Farinha
(ICOPEV 2022's Edition)
Polytechnic Institute of Castelo Branco, Portugal

CONFERENCE STEERING COMMITTEE

Anabela Tereso
University of Minho, Department of Production and Systems, Portugal

António Paisana
University of Minho, Department of Production and Systems, Portugal

Fernando Romero
University of Minho, Department of Production and Systems, Portugal

Filipa Vieira
University of Minho, Department of Production and Systems, Portugal

Jorge Cunha
University of Minho, Department of Production and Systems, Portugal

Madalena Araújo
University of Minho, Department of Production and Systems, Portugal

Manuel Lopes Nunes
University of Minho, Department of Production and Systems, Portugal

Paula Ferreira
University of Minho, Department of Production and Systems, Portugal

Paulo Afonso
University of Minho, Department of Production and Systems, Portugal

CONFERENCE ORGANIZING COMMITTEE

Carlos Sampaio
Polytechnic Institute of Castelo Branco, Portugal

Constança Rigueiro
Polytechnic Institute of Castelo Branco, Portugal

Daniel Raposo
Polytechnic Institute of Castelo Branco, Portugal

Domingos Santos
Polytechnic Institute of Castelo Branco, Portugal

Fernando Reinaldo
Polytechnic Institute of Castelo Branco, Portugal

João Neves
Polytechnic Institute of Castelo Branco, Portugal

João Sebastião
Polytechnic Institute of Castelo Branco, Portugal

José Metrôlho
Polytechnic Institute of Castelo Branco, Portugal

Luís Farinha
Polytechnic Institute of Castelo Branco, Portugal

Nuno Caseiro
Polytechnic Institute of Castelo Branco, Portugal

Ofélia Anjos
Polytechnic Institute of Castelo Branco, Portugal

Paulo Silveira
Polytechnic Institute of Castelo Branco, Portugal

Rita Cruz Tavares
Rethink Reserach Group, Portugal

Rogério Dionísio
Polytechnic Institute of Castelo Branco, Portugal

Rogério Ribeiro
Polytechnic Institute of Castelo Branco, Portugal

CONFERENCE CIENTIFIC COMMITTEE

Ana María Campón Cerro
Universidad de Estremadura, Spain

Ana Paula Silva
Polytechnic Institute of Castelo Branco, Portugal

Ana Vaz Ferreira
Polytechnic Institute of Castelo Branco, Portugal

Anabela Tereso
University of Minho, Department of Production and Systems, Portugal

António Paisana
University of Minho, Department of Production and Systems, Portugal

Arlindo Silva
Polytechnic Institute of Castelo Branco, Portugal

Benny Tjahjono
Coventry University Business School, UK

Carlos Lozano-Moncada
Escuela de IngenierÃ¬a Eléctrica y Electrónica, Universidad del Valle, Cali-Colombia

Carlos Sampaio
Polytechnic Institute of Castelo Branco, Portugal

Cláudio Barradas
Polytechnic Institute of Santarém, Portugal

Constança Rigueiro
Polytechnic Institute of Castelo Branco, Portugal

Daniel Ferreira de Azevedo
Polytechnic Institute of Viseu, Portugal

Daniel Raposo
Polytechnic Institute of Castelo Branco, Portugal

David O'Sullivan
National University of Ireland Galway, Ireland

Diego Manotas Duque
Escuela de Ingeniería Industrial, Universidad del Valle, Cali-Colombia

Domingos Santos
Polytechnic Institute of Castelo Branco, Portugal

Elide Di Clemente
Universidad de Estremadura, Spain

Enrique Arez
Escola Técnica Superior de Enxeñeiros Industriais, University of Vigo, Spain

Fernando Reinaldo
Polytechnic Institute of Castelo Branco, Portugal

Fernando Romero
University of Minho, Department of Production and Systems, Portugal

Filipa Vieira
University of Minho, Department of Production and Systems, Portugal

Hanna Włodarkiewicz-Klimek
Poznan University of Technology, Faculty of Engineering Management, Poland

Henk G. Sol
Faculty of Economics and Business, University of Groningen, The Netherlands

Isabel Soares
Faculty of Economics of Porto, University of Porto, Portugal

Joanna Kalkowska
Poznan University of Technology, Faculty of Engineering Management, Poland

João Lopes
Instituto Miguel Torga | Universidade da Beira Interior, Portugal

João Neves
Polytechnic Institute of Castelo Branco, Portugal

João Sebastião
Polytechnic Institute of Castelo Branco, Portugal

Joaquim Borges Gouveia
Universidade de Aveiro, Portugal

Jorge Cunha
University of Minho, Department of Production and Systems, Portugal

Jose Donizetti de Lima
Universidade Tecnológica Federal do Paraná, Brasil

José Javier Berrocal Olmeda
Universidad de Extremadura, Spain

José Manuel Hernández-Mogollón
Universidad de Estremadura, Spain

José Metrôlho
Polytechnic Institute of Castelo Branco, Portugal

José Soares da Fonseca
Faculty of Economics, University of Coimbra, Portugal

Kathryn Cormican
National University of Ireland Galway

Lígia Pinto
University of Minho, School of Economics and Management, Portugal

Luís Farinha
Polytechnic Institute of Castelo Branco, Portugal

M. E. J. O'Kelly
National University of Galway, Ireland

Madalena Araújo
University of Minho, Department of Production and Systems, Portugal

Manuel Lopes Nunes
University of Minho, Department of Production and Systems, Portugal

Mónica Costa
Polytechnic Institute of Castelo Branco, Portugal

Nelson Casarotto
Universidade Federal de Santa Catarina, Brasil

Nuno Caseiro
Polytechnic Institute of Castelo Branco, Portugal

INNOVATION & TECHNOLOGY

KNOWLEDGE & TECHNOLOGY TRANSFER

PROJECT MANAGMENT

SKILL DEVELOPMENT IN HEALTH SCIENCES
ACTIVE METHODOLOGIES IN HIGHER EDUCATION

Keywords:

Problem Base-Learning, Co-Creation, Team Building Frameworks, Design Thinking.

Authors:

Ana Borges[1]
Fernando Pereira[1]
Inês Barbedo,[1]
João P. Almeida,[2]
Paula Cabo[3]
Pedro Rodrigues[1]
Vera Ferro-Lebres[3]
Cláudia S. Costa[1]
Josiana Vaz[3]
Juliana Almeida-de-Souza[3]*

[1]Instituto Politécnico de Bragança, Portugal

[2]Research Centre in Digitalization and Intelligent Robotics (CeDRI), Polytechnic Institute of Braganca, Portugal

[3]Centro de Investigação de Montanha (CIMO), Instituto Politécnico de Bragança, Campus de Santa Apolónia, 5300-253 Bragança, Portugal

***Corresponding author:**
julianaalmeida@ipb.pt, Instituto Politécnico de Bragança, Campus de Santa Apolónia - 5300-253, Bragança, Portugal.

Abstract:

One of the biggest challenges today is to promote various teaching methodologies that accompany scientific, technological, social, cultural, economic, and environmental development, with a view to contributing to the training of professionals who know how to transfer theoretical knowledge to practice, in order to develop a more stable society. The main objective of this study is to understand whether active methodologies result in greater development of 21st-century capabilities in higher education. A systematic review of the literature was carried out, identifying published scientific studies on the subject under study, in the Scopus, Scielo, Web of Science, and PubMed databases, considering certain eligibility and exclusion criteria defined according to the MOOSE recommendations, and that allows us to answer the following research question: what does the literature review about active methodologies in higher education? According to the literature, active methodologies in teaching/learning have shown positive results and can be improved, successfully applied, and supported as creative and relevant pedagogical strategies. On the other hand, they present the most varied definitions, revealing a diversity of challenges and a variety of models that can be followed. This project work demonstrates that active learning methodologies, such as problem-based learning and co-creation, present themselves as innovative methods, used in different educational institutions, at the most different levels, and have achieved important results in learning and development of professional capabilities. As they are models that are neither fixed nor closed, they can be adapted to the different realities and needs of the courses and study contents.

INTRODUCTION

Focusing on the phenomenon identified, that is, the practice of different teaching methodologies that no longer focus on a methodology centered on the teacher, but on the student, this study can be divided into three main themes: teaching methodologies, problem-based learning, and co-creation. Where it was possible, in addition to the mere identification and description of studies already carried out, to deepen the theme, in order to discuss assumptions, concepts, processes, and results, to understand the meaning of the relationship between the theme and its context.

The main objective of this study is to understand whether active methodologies result in greater development of the capacities considered to be of the 21st century in higher education. More specifically, this also aims to explore these types of methodologies (in other studies and in practice), to analyze if there is any evolution of the intended capacities and what type of evolutions the students feel during this process.

This paper shows an overview of innovative learning method, with special focus on problem base-learning and co-creation, describing concepts, characteristics phases, including development, implementation, and evaluation, roles of the actors, advantages and disadvantages, this use in Health Sciences fields, other concepts to be considered, adaptations for e-learning, and final considerations.

NEW METHODOLOGIES

Education, as a dynamic process, requires a permanent update and change in its practices, with a view to developing activities different from those traditionally practiced. However, the teaching practice still today does not differ from what happened a long time ago, essentially consisting of the class model in which the teacher is the center of the process of transmitting concepts to students, who only receive and memorize the transmitted knowledge (Cavanagh et al., 2019; Gonçalves et al., 2020; Souza & Dourado, 2015; Swanson et al., 2019; van Karnenbeek et al., 2020).

One of the biggest challenges today is precisely to promote different teaching methodologies that accompany scientific, technological, social, cultural, economic, and environmental development, in order to contribute to the training of professionals who know how to transfer theoretical knowledge to practice, in order to develop a more stable and growing society (Gonçalves et al., 2020; Nagarajan & Overton, 2019; Souza & Dourado, 2015).

Some teaching methodological strategies have been developed by teachers, who believe it is possible to promote differentiated pedagogical practices, with a view to more meaningful learning. Often, innovative experiences are introduced from successful individual teaching practices, in which professors have achieved outstanding results in their pedagogical performance, thus facilitating their dissemination and expansion in other institutions. Thus, in contrast to the traditional teaching model, the experiences developed seek to innovate, with the aim of exploring new possibilities in the educational context and mobilizing significant processes of change (Souza & Dourado, 2015).

Today, in the 21st-century, students need a more diverse, complex, and integrated repertoire of knowledge and skills than any previous generation (Wulandari & Shofiyah, 2018). This diversity includes the ability for critical thinking and problem solving, creativity and innovation, collaboration and communication, and technological knowledge (Moustaffa, 2020; Nagarajan & Overton, 2019; Sari et al., 2021; Sriphong, 2019; Valtonen et al., 2021; van Karnenbeek et al., 2020; Wulandari & Shofiyah, 2018). It is necessary to activate strategies by which learning opportunities can be maximized, to enrich professional skills according to the demands of this century (Moustaffa, 2020). In this way, teachers must be selective in choosing models and learning processes that fit these requirements (Moustaffa, 2020; Sari et al., 2021; van Karnenbeek et al., 2020).

It is necessary to review the methodologies used or lack thereof, considering the perspectives of others, and providing effective learning content (Hemker et al., 2017; Sugino et al., 2016; van Karnenbeek et al., 2020). Learners need to choose appropriate learning strategies using learning content through consensus building (Hemker et al., 2017; Sugino et al., 2016; van Karnenbeek et al., 2020). Working with students is a key factor, as acquired knowledge tends to stay with young people (Han-Yu et al., 2018; Longoria et al., 2021; Martens, Meeuwissen, et al., 2019). Engaging students in content creation has been promoted to foster in-depth teaching and increase student engagement, resulting in superior conceptual understanding (Doyle & Buckley, 2020; Han-Yu et al., 2018; Martens, Meeuwissen, et al., 2019).

Thus, one of the main roles of the teacher is to create what is understood to be the appropriate learning environment for students. In this way, constructivist learning approaches that require the active involvement of students in the learning process emerge, emphasizing the importance of providing opportunities for students to build their own understanding of fundamental concepts and information (Doyle et al., 2021; van Karnenbeek et al., 2020).

Today, every European knowledge-based society requires a highly qualified and competent workforce, capable of adapting to modern innovative production. Educating such specialists is the goal of contemporary teachers. Thus, efficient, and innovative pedagogical education becomes an integral part of the European education system (Roliak et al., 2021; van Karnenbeek et al., 2020). For this very reason, education must become a "practice of freedom" that develops "critical awareness" among its students (Cavanagh et al., 2019; van Karnenbeek et al., 2020). They must leave behind the passive role in their training and become actively involved in their learning (Dreyer et al., 2021).

Evidence suggests that more traditional teaching methods do not allow all students to adequately engage with the types of academic literacy that are constitutive of higher education. Academic discussion around the issue can allow students to build a rich understanding of the different types of knowledge and skills needed to meaningfully engage with broader academic communities. Therefore, one should consider the combination of learning methods that focus on academic discussion and deep processing (Ribes-Giner et al., 2016; Souza & Dourado, 2015; Swanson et al., 2019; Tarı Kasnakoğlu & Mercan, 2020; Wulandari & Shofiyah, 2018).

Current higher education literature strongly positions students as active participants in their learning and underestimates the contribution of critical pedagogy that spoke of negotiated curricula and the active role of students from the point of transformation and democratization of processes in education (Kaminskiene et al., 2020). This means that it is important to strengthen interactions between students, faculty, staff, and the community to enhance learning experiences (Ribes-Giner et al., 2016). Additionally, the integration of both research and evidence is now considered critical. The relationship between research and teaching has evolved and been influenced by several factors (Pezaro et al., 2022).

With global trends toward increasing personalization and expectations of higher education, the question of how to design relevant, high-quality counseling services at scale that support learning outcomes, enhance the student experience, and enhance student acquisition employability is a challenge (Han-Yu et al., 2018; Mann, 2020). Several points to the disparity between the skills required in society/work (decision-making, problem-solving, and management skills), and those that current university students are being taught (Hortigüela Alcalá et al., 2019). The transversal competencies address different thematic axes, from knowledge of a foreign language to teamwork. It is precisely on this "transversality" that the main objective of teaching in higher education is based, as professors work on common axes throughout courses that must have direct transfer to society in general and to the world of work. Some of the most common transversal skills are analysis and synthesis, organization and planning, communication, collaboration, the development of interpersonal skills, and the use of information and communication technologies. On these, it is essential for university students to achieve critical ability, creative ability, communicative ability, and collaborative ability (Hortigüela Alcalá et al., 2019).

In this scenario, and with a view to a reorientation of directions, to satisfy the demand for new ways of working with knowledge, we seek to encourage teachers to research innovative methodologies that enable the development of students' skills for problematization as a fundamental component of a method that is centered on learning. The focus on problematization enables a transdisciplinary view and has as its starting point the raising of questions and the search for solutions to the problems identified, at the respective levels of learning, to produce knowledge (Bovill, 2020; Han-Yu et al., 2018; Commission, Directorate-General for Research and Innovation, 2021).

Many changes have occurred in the field of training of health professionals (Roliak et al., 2021; Swanson et al., 2019), following the European global context of changes in education and health policies, which seek to meet a globalized academic training, with a view to the professional who wants to train as a thinking being and with a humanized view of the patient. National and international forums have highlighted the need to reorient the teaching/learning of courses in the health area, reviewing not only the curricular contents but also the teaching methodologies and training of teachers involved in the process (Cavanagh et al., 2019; Gonçalves et al., 2020; Ibrahim & Al-Shahrani, 2018; Morgado et al., 2021; Pezaro et al., 2022).

Health problems are multidimensional, simultaneous, and non-linear. Diseases and conditions are present at the same time, in different degrees of progression and severity (Dreyer et al., 2021; Morgado et al., 2021). Therefore, healthcare professionals need to improve the use of several vital and critical capabilities to provide quality and safe healthcare for patients. These include teamwork and collaboration, patient-centered care, evidence-based practice, quality improvement, security, and informatics (Allert et al., 2022; Dreyer et al., 2021; Morgado et al., 2021). The purposes of these requirements were to emphasize the meaning and understanding of concepts and principles; integrate the teaching of different subjects into the basic sciences, provide early clinical exposure; and improve clinical skills learning. Considering these requirements, with changes in clinical practice and social demands, there is a need to move towards an innovative and integrated curriculum centered on students (Ibrahim & Al-Shahrani, 2018).

New models of health education emphasize the importance of context and content for the implementation of significant therapeutic actions. One way to stimulate this change is through active education methodologies (Cavanagh et al., 2019; Dreyer et al., 2021; Morgado et al., 2021).

Various approaches and models have been introduced to develop ways that are more focused on teaching, learning, and student. This is reflected in the growing body of educational literature on active approaches to learning, such as design-based research, participatory design, co-cre-

ation, co-design, student voice, student-team partnership, problem-based learning, ~~classroom~~ flipped classroom and students as agents of change, student engagement, and empowerment (Martens, Meeuwissen, et al., 2019; European Commission, Directorate-General for Research and Innovation, 2021).

Thus, in the health area, concepts such as "Problem Base-Learning" and "Co-Creation" emerge as innovative learning methods, in contrast to didactic teaching models supported by so-called traditional perspectives. In recent years, they have gained space in numerous educational institutions, especially in higher education institutions (Menezes-Rodrigues et al., 2019). In this sense, it is important to know and understand these processes.

Such methodologies are, therefore, innovative strategies in which students work with the objective of solving a real or simulated problem, from a context. They are, therefore, learning methods centered on the student, who leaves the role of a passive receiver of knowledge and takes the place of the protagonist of their own learning, through research (Bovill, 2020; Dollinger & Lodge, 2020a; Gonçalves et al., 2020; Kaminskiene et al., 2020; Martens, Spruijt, et al., 2019; Souza & Dourado, 2015; Swanson et al., 2019).

These approaches are in line with current educational goals, such as acquiring the skills needed for the 21st-century and providing strong content experience along with more general skills, such as problem solving and collaborative skills (Hortigüela Alcalá et al., 2019; European Commission, Directorate-General for Research and Innovation, 2021; Valtonen et al., 2021).

According to existing studies, these methodologies have shown positive results, and can be successfully improved and supported as creative and relevant pedagogical strategies (Bovill, 2020; Gonçalves et al., 2020; OECD, 2016). These include generative dialogue, negotiation, collaborative work, and participatory design model, among others (Bovill, 2020; Kaminskiene et al., 2020).

On the other hand, the literature presents the most varied definitions of the methodologies in question, revealing a diversity of challenges that current teachers and students face (Bovill, 2020; Gonçalves et al., 2020; Kaminskiene et al., 2020; Martens, Meeuwissen, et al., 2019; Martens, Spruijt, et al., 2019; Swanson et al., 2019). As such, and above all because they are increasingly discussed and applied, it is important to address the lack of a current review on the subject in the existing educational literature (Bovill, 2020; Gonçalves et al., 2020; OECD, 2016; Kaminskiene et al., 2020; Martens, Meeuwissen, et al., 2019; Martens, Spruijt, et al., 2019; Souza & Dourado, 2015; Swanson et al., 2019).

Each one of them brings important contributions to the understanding of its meaning, which allows a better development of the application process, in the most diverse areas of knowledge and levels of education, contributing to the advancement of this field. The analysis of these concepts will contribute to the understanding of how these methodologies can transform the pedagogical interaction of students and teachers, learning, and the impact on the process in all its phases, from development, implementation, and evaluation.

PROBLEM BASE-LEARNING (PBL)

Definition

Problem-based learning (PBL) is an innovative instructional approach to student-centered instruction, in which the student works toward solving a real or simulated problem from a context (Dreyer et al., 2021; Ghani et al., 2021; Kibret et al., 2021; Moustaffa, 2020; Souza & Dourado, 2015; Wulandari & Shofiyah, 2018).

The learning problem "is a description of phenomena or situations that need explanation, often presented in textual format, with illustrations, diagrams, among others". The problem, both theoretical and practical, is the starting point directing the student's educational process. Problems for learning are also called tasks, stimuli, or statements that describe a specific scenario, and even projects, in a much broader meaning, with students learning best when applying knowledge based on theory and research to their work, with an authentic problem. (Chang et al., 2017; Martens et al., 2020).

At the same time, this methodology helps students to develop flexible knowledge, effective problem-solving skills, self-directed learning, effective collaboration, and intrinsic motivation. In addition to providing more in-depth learning, compared to the traditional method, PBL allows students to learn/acquire important skills and qualities such as interpersonal skills, critical thinking, decision-making, reasoning, and use of different sources of information, teamwork, cooperation, respect for group members, curiosity, and patience (Dreyer et al., 2021; Ghani et al., 2021; Juuso, 2018; Khatiban et al., 2019; Kibret et al., 2021; Moustaffa, 2020; Sriphong, 2019; Valtonen et al., 2021; Wulandari & Shofiyah, 2018).

In this way, and taking this method into account, the learning process can be divided into five stages: "propose a problem - establish a hypothesis - collect data - demonstrate hypothesis - summarize". Learning takes place in complex but significant problem situations where the team works together to solve problems, acquire the knowledge behind that problem and then develop knowledge to solve it and develop the ability to learn from it. (Han-Yu et al., 2018; Martens, Spruijt, et al., 2019; Valtonen et al., 2021). In this way, the teacher acts as a facilitator who guides students' learning, while they are forced to solve problems, discussing them with group members (Ghani et al., 2021; Martens, Spruijt, et al., 2019). All this has caused considerable confusion about what kind of education "PBL" designates, raising questions about the most varied differences in the interpretation of this methodology, and whether such differences extend the term "PBL" too far, to the point of ceasing to mean something specific (Martens et al., 2020; Souza & Dourado, 2015).

In PBL, although its approach is interdisciplinary, there is a need to explore precisely what this means in practical terms and what it means not only for students but also for teachers and institutions (Baldwin, 2017; Souza & Dourado, 2015). It is therefore important to clarify the extent to which the principles and practices underlying the programs, which can credibly claim to have initiated the problem-based movement in higher education, overlap or diverge (Martens et al., 2020).

Furthermore, this methodology has been actively developed and used in higher education (Souza & Dourado, 2015; Valtonen et al., 2021), has received much attention in recent years (Han-Yu et al., 2018), significantly increasing the usability of knowledge acquired at university: the transfer of theoretical knowledge to professional situations, on the one hand, and the direct acquisition of practical knowledge, on the other (Hemker et al., 2017). Likewise, it has shown

positive results, observed by researchers from most different areas (Han-Yu et al., 2018; Hemker et al., 2017; Kibret et al., 2021; Souza & Dourado, 2015), but always referring that there is still room for improvement (Hemker et al., 2017; Kibret et al., 2021).

In the learning situation, students' perceived self-efficacy will affect their academic interest, learning motivation, emotional management, cognitive ability, and growth achievement. Self-efficacy has a strong mediating effect on the subsequent performance and self-actualization of individuals. PBL can help students acquire the professional knowledge and skills required in the workplace. However, while this knowledge can increase learning effectiveness, if self-efficacy is not a prerequisite for operation, its effectiveness is difficult to demonstrate. Therefore, the problem-oriented learning teaching strategy should emphasize the need to establish short- and long-term goals, and give performance feedback, as a source of information to improve learning and thus, consequently, improve self-efficiency. This method is a complete learning strategy, in which the theoretical foundations are derived from modern theories of learning, such as the cognitive school and the constructivist school. PBL emphasizes that learning is an active mental process that uses a student's previous experiences and develops the connection between previous information and new information, in the construction and formulation of hypotheses or theories. It also connects facts and theoretical information with practical dimensions to gain a deep understanding of a concept. Social foundations can also be shown in the PBL when peer groups collaborate to build knowledge. Thus, it arises because of student procedures or actions (Chang et al., 2017; Dreyer et al., 2021; Ghani et al., 2021; Han-Yu et al., 2018; Juuso, 2018; Khatiban et al., 2019; Kibret et al., 2021; Martens et al., 2020; Martens, Spruijt, et al., 2019; Moustaffa, 2020; Souza & Dourado, 2015; Sriphong, 2019; Valtonen et al., 2021; Wulandari & Shofiyah, 2018).

Characteristics

In the extensive literature produced on PBL, there is a consensus on its basic characteristics. In common perception, all point out that this methodology promotes the acquisition of knowledge, and the development of skills, competencies, and attitudes throughout the learning process, in addition to favoring the application of its principles in other contexts of the student's life. Thus, PBL presents itself as a didactic model that promotes integrated and contextualized learning (Martens, Spruijt, et al., 2019; Moustaffa, 2020).

In general, PBL has five fundamental characteristics, (1) the use of problems as the beginning of the learning process, (2) collaborative learning in groups, (3) student-centered learning, (4) the role of teachers and (5) enough time for self-examination (Gonçalves et al., 2020; Liu et al., 2019; Souza & Dourado, 2015). This method emphasizes active participation, problem-solving and critical thinking. PBL encourages students to identify their knowledge and skills and apply them to new situations or use them to achieve specific goals, combining previous knowledge or principles, which makes PBL distinct from other methods (Liu et al., 2019; Souza & Dourado, 2015).

Souza & Dourado (2015) specifically mention three of these characteristics, as they are considered pillars for the positive functioning of this methodology, compared to the traditional one: the student as a learning center, group work, and the teacher as a tutor.

In the case of the student as the center of learning, the study suggests offering students more possibilities to develop their studies independently, making the student the protagonist of their own learning, feeling motivated and valued for their acquired knowledge. of other experiences throughout life, expanding and developing their potential for new learning. Thus, these become self-directed, self-oriented, and motivating from the teacher to the student as the center

of the teaching and learning process, leading him to the understanding that learning is not just acquiring information, but processing it to transform it into knowledge. That is, through its applicability, we are enabling the development of educational activities that involve individual and group participation in critical and reflective discussions, converting the activities developed in the classroom into rich and significant situations to produce knowledge and learning for life. This allows access to different ways of learning and, especially, of learning to learn. Under such conditions, students will be able to learn by practicing what their future profession will be, becoming active professionals able to solve, with autonomy and responsibility, the problems that will arise in their daily lives (Souza & Dourado, 2015).

In relation to group work, the same says that it promotes collaborative learning and that it is an opportunity for personal and social training. Collaboration provides space for the reconstruction of knowledge, for the analysis and interpretation of data, for the comparison of divergent points of view, and for the explanation of concepts and ideas. Thus, the creation of a collaborative climate is also a source of values among the students who form the group: the ability to listen and observe what the other says; the solidarity that arises spontaneously and the solidarity that is built among all; the search for truth in the relationships and in the way of acting of each and every one of the members; the potential to correct each other and the expectation of the common learning rhythm, considering the time of each one. Acquiring these lessons is an opportunity for enriching growth, which only collaborative work facilitates. In this sense, collaborative group learning in higher education is a process of cultural change; the teacher is the agent of this change when, in the academic space, he facilitates learning through these methods. This group learning, through PBL, is more of a process than an outcome (Souza & Dourado, 2015).

Regarding the teacher as a tutor/facilitator, he points out that education, as it is a dynamic process, demands from the teacher a permanent update and change in their teaching practices, with a view to developing skills different from those traditionally exercised. In terms of knowledge, the minimum required of a teacher is mastery of the content of their discipline, constantly keeping scientific knowledge up to date, to respond to the demands of the evolution of knowledge and the demands of society. He must also know the contribution of his discipline to technological advancement and identify the ethical values present in society. In the didactic-pedagogical dimension, it is important for the teacher to know the psychological processes that affect learning, as well as the didactic methods and strategies that, according to the characteristics of the discipline, best favor learning (Souza & Dourado, 2015).

Since the problem is the vehicle of the ABP, Gonçalves et al. (2020) enumerated the main components that characterize a so-called "Good Problem". This must consist of the neutral description of a phenomenon that needs explanation, formulated in concrete, simple and objective terms; should be relatively small, directing the student to a limited number of topics, activating prior knowledge, and not requiring extensive hours of individualized study to acquire adequate knowledge regarding the phenomenon in question. It must, likewise, can lead and motivate learning, not containing topics that lead to distractions, and use cases that address socio-environmental issues, thus promoting a critical reflection on the part of the student. It should also require judgment and decision-making and raise open-ended questions that stimulate discussion. The same study indicates the importance of the problems to be studied, in each tutorial discussion, to be elaborated in advance, as well as the learning objectives to be achieved.

PBL is founded on the principles that knowledge is constructed and shaped in a social context and uses problem cases as vehicles for learning. The judicious use of problematic cases serves to reinforce the learning process, as well as specify the learning objectives. Peer discussions are not aimed at reaching a single solution, but serve to cultivate the principles of problem-solving, creativity, and openness. The learning process aims to enable students to select their learning

goals and experiences, thus cultivating the spirit of self-reflection. Students become structures of their knowledge and develop responsibility for learning. However, other dimensions of learning are also mobilized with this methodology, such as: motivation, which is stimulated by a curiosity about the themes of each area of study; individual and group communication skills, essential for the development of group learning; and the ability to write scientific articles, which starts from the idea of students analyzing and understanding existing phenomena in order to express themselves better (Compton et al., 2020; Sari et al., 2021; Souza & Dourado, 2015; Sriphong, 2019;).

Phases

The PBL has a basic structure governed by general principles that allow it, according to the school level, university course and discipline, to model itself to meet each of the specifics. The basic structure takes place in four stages: the first begins with the choice of the real context of the student's lives, for the identification of the problem and the preparation and systematization, by the teacher, of the materials necessary for the investigation. The second stage follows with the students receiving the problematic context from the teacher. They start the process of elaborating the problem questions about the context of which they have previous knowledge and that they will deepen. Then, we move on to the discussion of the questions in the group to, from there, start the investigation planning, for the resolution of the same. The third stage is the investigation development process, through the various resources made available by the professor. Students, at this stage, acquire information through reading and critical analysis, research, discussion in groups, and raising hypotheses for a solution. In the last stage, they elaborate a synthesis of the discussions and reflections, systematize the solutions found to the problems, prepare the presentation, and promote the self-assessment of the learning process they carried out. Thus, in a simplified way, and according to Gonçalves et al. (2020), Sari et al. (2021), Souza & Dourado (2015), and Sriphong (2019), the following steps can be pointed out:

- First stage: elaboration of the problematic scenario or context;
- Second stage: the problem questions;
- Third stage: problem-solving;
- Fourth stage: presentation of the result and self-assessment.

More specifically, seven steps to follow were also pointed out, considering the steps already mentioned. Since, steps 1 to 5 are performed in the first stage (considered as "opening"), step 6 in the second stage, which occurs outside the group, and step 7 in the third stage (considered as "closing"). Therefore, the process of this methodology can follow the following order (Gonçalves et al., 2020; Sari et al., 2021; Souza & Dourado, 2015; Sriphong, 2019):

1. Reading the problem, identifying and clarifying unfamiliar terms;
2. Identify the problems, raising the points of doubt that will raise the discussion;
3. Survey of explanatory hypotheses, resuming previous knowledge;
4. Summarize the discussion, recalling the problems listed, the diagnostic hypotheses raised, the contributions of previous knowledge, and the pros and cons. This helps to identify the study objectives;

5. Formulation of learning objectives in order to guide the study, identifying points of relevance;

6. Individual study of the issues raised in the learning objectives, looking for scientific references, validating/invalidating hypotheses, and filling knowledge gaps;

7. Group shares the solution to the assigned problem and the acquired knowledge.

The benefit of the interaction promoted by PBL is fundamental to achieving success in its application. It is necessary for every way: with the subject and with the context of the subject studied, between the students and the teacher. The structure of this methodology is built on this basis since the interaction is the key to the learning process (Souza & Dourado, 2015).

Assessment

In the teaching and learning process, assessment is a fundamental element. In PBL, this practice should be developed as part of learning and not just as a mechanism for quantitative attribution of a classification. After all, it is precisely through the evaluation activity that the student's feedback is obtained, about their difficulties in the learning process, so that there is time for the teacher to reorient the topic or content studied, correct misunderstandings, and enable the return to the desired path. In this way, the use of this method requires a change in the conception and execution of the evaluation, since the objectives are not limited to the mere learning of conceptual knowledge by the students, but the development of mental competencies, directed to at least three capacities: scientific understanding, through real-world cases, reasoning and problem-solving strategies, and self-regulated and self-directed learning strategies (Roliak et al., 2021; Souza & Dourado, 2015).

Another important point is that the teacher understands that, in PBL, it is essential that students show themselves capable of developing their skills to think in a critical and contextualized way; analyze and synthesize the information; build a solid argument, justifying their results well and producing knowledge autonomously; interact collaboratively; demonstrate organization in the presentation of results and know how to communicate, with clarity and confidence, the results achieved, both in written and oral modality. Thus, the teacher must define which elements should be evaluated and how to evaluate them. This makes an assessment in PBL one of the great challenges of teaching (Roliak et al., 2021; Souza & Dourado, 2015).

According to Compton et al. (2020), in general, students believed that the modules of this method and the assessment criteria applied were effective in facilitating and evaluating their learning, although they recognized that they did not see the research as significant in supporting their future practice and showed some hesitation in adapting to this methodology.

Teacher/Student

The discussion around the use of active learning processes by teachers and students has gained increasing relevance at all educational levels (Menezes-Rodrigues et al., 2019).

In this teaching-learning context, the student should not be seen as a passive agent but encouraged to actively participate in the construction of knowledge, through the search and analysis of available information. Their participation and commitment in this learning process become progressively greater, since the responsibilities assigned increase with the application of successive problems that seek to awaken independence and autonomy and a lesser need for guidance. Students develop autonomy and independence while building their own knowledge. Such characteristics

favor them in the search for knowledge, in the consolidation of ethical, fundamental, and specific concepts in different courses, in addition to promoting social interaction and strengthening the humanization process during their training (Gonçalves et al., 2020; Menezes- Rodrigues et al., 2019; Roliak et al., 2021).

The key point in this learning is the self-assessment of one's own projects, efforts, motivations, interests, and levels of productivity. Students thus become critical individuals, giving each other constructive feedback, which helps them to become aware of their own strengths and improve their interactions with each other (Wulandari & Shofiyah, 2018).

For most students, PBL is much more interesting, stimulating, and enjoyable than traditional teaching methods (Souza & Dourado, 2015). On the other hand, according to McKenzie & Brown (2017), the application of this method initially proved to be difficult and stressful for many of the students, who were not familiar with learning independently and were reticent with the assessment proposal. However, they highlighted the important value of constructive feedback and how it helped them.

The PBL is a method that considers as one of the fundamental points of its application the relationship between the teacher, the student, and the content to be studied and learned. The teacher assumes the role of facilitator, tutor, mediator, guide… who encourages students to discover, interpret and learn. In addition, it contributes to the development of a series of didactic principles that link teaching and learning to real situations, reinforcing the independent, active, and responsible activity of the student in the construction of new learning (Gonçalves et al., 2020; Roliak et al., 2021; Souza & Dourado, 2015).

The acknowledgment of the facilitator's importance is accompanied by an attempt to delimit his/her profile, which is basically defined by assuming responsibility for creating and presenting the problematic scenario; collaborating with the learning process; helping in learning the conceptual knowledge of the discipline; monitor the process of investigation and resolution of problems; enhance the development of skills for analyzing and synthesizing information; be co-responsible for organizing the meeting space and group relationships; and favoring creativity that provides students with independence when approaching cognitive processes (Gonçalves et al., 2020; Martens et al., 2020; Roliak et al., 2021; Souza & Dourado, 2015). All these characteristics are fundamental in the process of applying this methodology (Souza & Dourado, 2015).

Thus, it is essential to prepare teachers for the implementation of this type of methodology, and Roliak et al. (2021) point out as key points:

- not restricting students in the process of formulating new ideas;
- not trying to find the only right way to solve the problem;
- avoid intervening without reason, so as not to interrupt the group's autonomy;
- not prematurely criticizing new ideas and giving students complete freedom in the search for new theoretical and information sources, for the creation of their own approaches in problemsolving situations.

Despite the positive results related to the methodology, teachers and students must be aware of their proper roles during the process, since changes in the application of PBL can negatively interfere with the learning process, leading to the failure of this method. The lack of understanding of the fundamentals and underlying principles, and the misguided attempts to promote a more

efficient, result-oriented approach, contribute to the failure of the principles of problem-based learning, leading to the discontent of all those involved in this process (Gonçalves et al., 2020).

Implementation

Regardless of all the benefits of PBL, it is necessary to provide an environment with certain conditions, and in accordance with its basic principles that prepare students and teachers for change, so that it can be successfully implemented (Moustaffa, 2020).

Although this method has many applications, its implementation is based on a single universal workflow structure that contains three elements: the problem as an initiator for learning, the teacher as a facilitator, and group work as a stimulus for collaborative interaction. These revolve around four types of learning principles: constructive, self-directed, collaborative, and contextual. Thus, the practice of this methodology helps the student to understand the content, form a new opinion and acquire new knowledge (Ghani et al., 2021; Sari et al., 2021).

Ghani et al. (2021) identified the essential learning behaviors necessary for the effective implementation of PBL in higher education, grouping them into three main themes: intrinsic power, trust, and functional capabilities. These must coexist to ensure the desired learning outcomes in this methodology.

Intrinsic power is seen as the application of students' inner strength in carrying out positive learning behaviors. That is, it requires students to proactively engage in the learning process, organize their activities systematically, persevere in learning and be resourceful. Therefore, the power of students' intrinsic behavior can improve their learning, allowing them to decide on their goals and promoting their own confidence to achieve goals (Ghani et al., 2021).

Trust is the role given to students to get them involved and identify gaps in their learning. These should engage in self-assessment, give constructive feedback, and value the feedback received. By assigning an active role to students, an opportunity and responsibility are given to them to elaborate their learning and become experts, promoting deep learning (Ghani et al., 2021).

Functional capabilities are considered essential for the competent performance of a task in the PBL. These require the student to organize and plan time for specific tasks, have digital skills, use data effectively, and work together efficiently to achieve agreed goals. These undoubtedly help students with the skills and knowledge necessary for the success of this methodology. Studies have shown that strong time management skills, digital knowledge, data management, and collaborative capabilities not only lead to positive academic performance but also prepare them for future job positions (Ghani et al., 2021).

Despite the PBL's merit, there are several challenges in its implementation, including the lack of learning resources, the need for a longer period, the weak training of teachers, the lack of research on the nature of the problems that can be introduced to students, the potential difficulty others might face in adapting a new teaching approach, and confusion about the methodology itself. Such challenges can, however, be overcome through the prior presentation to students and teachers of the methodology implementation process, the presentation of other success cases as an example, and the reconstruction of both the various activities and the workload of the discipline in question (Hemker et al., 2017; Sari et al., 2021).

Advantages and disadvantages

In recent decades, PBL has adapted to different areas of knowledge. However, despite all the advantages enumerated by the various studies carried out, there are some difficulties in the use of this methodology, on which it is necessary to reflect (Souza & Dourado, 2015).

The recognition of the advantages of this method compared to traditional teaching has promoted a greater diffusion of it, which is currently used in different areas of knowledge and in different courses. Therefore, the following advantages can be listed (Chang et al., 2017; Souza & Dourado, 2015):

- Motivation: a fundamental element of learning, as it arouses the student's interest and curiosity for the topics studied in order to obtain quality learning, which will generate greater satisfaction;

- Integration of knowledge: when developing new knowledge relating it to previous knowledge, the integration of learning occurs, which allows the transfer, expansion, and duration of the knowledge produced;

- Critical thinking: the complexity and diversity of the training and performance fields require the student to develop the ability to think critically about knowledge, and to carry out a permanent investigation of information and knowledge;

- Interaction and interpersonal skills: imply a general relationship between all those involved in the classroom, as it provides learning not only from the results of academic research activities but also seeks to achieve broader learning, of an interpersonal educational character to develop affective capacities, coexistence, and personality of the students.

On the other hand, as disadvantages/difficulties can be pointed out (Chang et al., 2017; Souza & Dourado, 2015):

- Initial insecurity: change of teaching method, because the new one brings concerns, doubts, and questions, unlike a conventional teaching method;

- Time: with PBL, more time is needed for students to reach a satisfactory level of learning;

- Inadequacy of the curriculum: as it is a question of working with problems, the learning contents can be approached differently and with greater or lesser depth in the various disciplines;

- Financial resources: more institutional support regarding the availability of financial resources;

- Assessment: it is a difficult task for students who are not used to the type of assessment that includes self-assessment and assessment of group members in the presence of the facilitator;

- Changing the role from teacher to facilitator: not all teachers have the necessary training for certain dynamics of this method, which can lead to a real failure in using it.

Health Sciences Area

Due to current changes in healthcare realities and the continuous expansion of knowledge, there is a growing demand for cognitive and problem-solving skills to recognize the needs of patients and society (Ibrahim & Al-Shahrani, 2018). Among the many educational methods used to foster clinical reasoning, problem-based learning is one of the most used (Merisier et al., 2018).

However, despite the positive results, compared to conventional education, in terms of improving student performance and acquired skills (Allert et al., 2022; Khatiban et al., 2019; Kibret et al., 2021; Liu et al., 2019), many authors argue that more empirical evidence is needed to obtain a better understanding of the benefit of this type of methodology, to promote students' clinical reasoning (Chang et al., 2017; Kibret et al., 2021; Merisier et al., 2018).

Approaching the field of health sciences in general, this type of active methodology promotes greater commitment, involvement, increased motivation, assiduous reading of the indicated references, and improvement of the understanding and assimilation of the contents given in the different disciplines, for the formation of the students of the different health courses at the higher level (Menezes-Rodrigues et al., 2019).

According to Kibret et al. (2021), most students agreed that PBL was useful for understanding basic science knowledge, helped to develop problem-solving skills, and motivated students to learn. Likewise, regarding assessment, some of the students admitted that they did not find the teachers prepared and qualified to use this method.

Likewise, Merisier et al. (2018) analyzed the contribution of PBL to the development of clinical reasoning and the assessment of critical thinking. Although critical thinking skills are necessary for reasoning, they argue that clinical reasoning goes beyond critical thinking. The authors concluded that although this methodology creates a learning context favorable to the development of clinical reasoning skills, the result depends a lot on the educational strategies used by teachers and students.

Also, Menezes-Rodrigues et al. (2019) give us an overview of the results obtained in the implementation of this method in the different areas of this field. In the area of dietetics and nutrition, this study concluded that, carrying out problem situations, group evaluations, and the use of interventions and the application of tests used as diagnostic evaluation, favored a better formation of future professionals. In nursing, it discusses the importance of ethical competence and its applicability in care, as well as the need for this type of methodologies so that students can develop interactive, more ethical, solidary, and humanized actions. In the field of physiotherapy, he considers that, for the formation of a more reflective, critical, and humanistic professional physiotherapist, PBL should be used and experienced as an active learning method. In pharmacy, and according to the students, this methodology promoted a noticeable improvement in student performance and highlighted an increase in the motivational effect that made students more interested in the content and developed logical reasoning, through the contextualization of the theoretical knowledge with the practical situations inherent in the pharmaceutical profession.

Colleges and higher schools of pharmacy increasingly use this type of active learning as an educational tool to improve the learning and training of pharmacy professionals (Liu et al., 2019; Menezes-Rodrigues et al., 2019; Newsom et al., 2019). Liu et al. (2019) demonstrated the positive effect of PBL on students, not only in obtaining higher theoretical classifications in pharmacology, but also in improving self-study, learning interest, team spirit, problem-solving, analysis, communication, and expression. As pharmacology is an increasingly fast science, with changes in the number of drugs, knowledge of mechanisms of action and other information, a

change in the curriculum seems to be beneficial in the better preparation of these professionals, who, throughout their lives, will be better able to deal with changes in knowledge and skills associated with progressive and dynamic social/economic transformation. The study also states that these results support conclusions obtained in other research in the areas of nursing, medicine, and dental education.

PBL is increasingly used in medical programs around the world. However, more evidence is needed to support the idea that this methodology is more effective than traditional methods. Teachers in this area are naturally interested in knowing whether it contributes to the desired skills of future doctors. However, a portion of them remain sceptical about whether PBL will be equally effective in teaching and, if so, whether it is possible to do so without overusing existing resources (Liu et al., 2019). Stentoft (2019) explored the many possible forms of PBL and how they promote different learning objectives. He also points to the creation of taxonomies, to categorize implementations of this method, according to key variables related to student and faculty involvement, and the nature of the problems. All these taxonomies share the view that PBL is linked to narrow learning objectives, where facilitators define objectives, through case-specific materials and learning steps. However, the same study concludes that this methodology can be more than that.

In the area of nursing, Khatiban et al. (2019) recognized PBL as a method to improve critical and creative thinking among nursing students in ethics education. It also reports that this method significantly improves students' problem-solving skills, critical thinking, metacognitive awareness, and learning progress. On the other hand, some students recognize that they have suffered more stress due to schoolwork, compared to the traditional method.

PBL in the health sciences, there are several issues for curriculum design and implementation that need to be addressed, such as staff, learning resources, different approaches, time, workload, learning objective, evaluation, among others. Recently, modified techniques of this methodology have been introduced in this field, such as the use of "real" patients as a stimulus for learning ("key case" approach) (Chang et al., 2017). Most authors advocate the use of a hybrid PBL model as the main teaching and learning tool in this area (Chang et al., 2017; Ibrahim & Al-Shahrani, 2018; Khatiban et al., 2019; Liu et al., 2019; Stentof, 2019).

Online

In online classes, PBL activities can be developed in Problem Base Learning - Virtual (PBL-V), which is a learning approach that presents contextual problems, to encourage students to learn online. Like PBL, PBL-V is a learning model that presents challenges for students to acquire methods of working in groups, to find solutions to real-world problems (Fitriana et al., 2021).

The main purpose of PBL-V is not to convey most of the content during virtual learning, but to develop students' critical thinking skills, and the ability to independently build their understanding and problem-solving skills and, at the same time, develop skills to actively build their knowledge. PBL-V also aims to develop students' independent learning and social skills through online learning. Learning independence and social skills can be formed when students collaborate to identify information, models, and learning resources relevant to learning completion (Fitriana et al., 2021).

In this field, certain advantages and disadvantages were pointed out. As advantages, it described the fact that it is easier for students to understand a concept that is built by themselves, especially supported by the ease of access to online literature. It was also mentioned that the teacher directs

the correct concept during the discussion, actively involving students in problem-solving and demanding greater thinking skills, as well as the fact that students can feel the positive impact of learning since the problems that are solved are directly linked to real life. There is thus a greater motivation to learn, arousing interest in the material being studied, making students more independent and mature, able to give and accept opinions, and instilling a positive social attitude. On the other hand, the disadvantages include the preparation of learning (tools, problems, and concepts) which is complex, the difficulty of finding relevant problems, the misunderstandings that often occur, and the fact that there are restrictions on the internet network in the access to literature, in online learning activities (Fitriana et al., 2021; Morgado et al., 2021).

This model can be considered a relevant learning tool, to be used within the specific context of education, in health sciences, demonstrating benefits when compared to traditional learning strategies. According to the results reported by Morgado et al. (2021), students prefer a hybrid PBL system, rather than the conventional one, in a distance learning context. On the other hand, the thoroughness of knowledge is perceived as inferior to that obtained through the conventional method. According to these students, the online PBL method is not a reliable tool to facilitate learning in a clinical setting, compared to other methods. However, the online PBL strategy can be seen as a successful instrument to improve the advancement of information and clinical capacity (visual/spatial and auditory) in this area, with results like those obtained in the current environment.

According to Fitriana et al. (2021), about 53% of students report that they "Strongly agree" and 20% of students "Agree" with the use of PBL-V in virtual teaching/learning. This is because the material presented can be easily found in the online literature and so they can study any topic, with new experiences in learning, increasing the constructive capacity of knowledge independently. However, about 17% of students "Neither Agree nor Disagree", 3% "Disagree" and 7% "Strongly Disagree". These results can be explained by the difficulty of accessing the internet. Likewise, some of the students stated that they were still used to conventional learning, tending to be happy to receive information directly from the teacher, rather than independently.

Other concepts

As mentioned earlier, other modified problem-based learning techniques have emerged. These include Project Base-Learning, Case-Base-Learning, Self-Directed Learning, Team-based learning, and Service Learning. Problem-Based Service Learning.

Project Based Learning (PBL)

Project-based learning is a model where teachers act as facilitators, guiding students through a research process that includes working collaboratively to develop a product, testing a prototype/plan, and reflecting on the entire experience (Nagarajan & Overton , 2019).

Although PBL and ABP are student-centered approaches, there is some disagreement in the literature on whether they are similar or very different approaches. The fundamental principles remain the same and can be expressed along three axes: learning, content, and social aspect (Martens et al., 2020). However, in PBL, projects do not include detailed descriptions of activities or time periods, since the learning objectives are broad and must be defined by the students themselves, in collaboration with the teacher, who becomes a supervisor (Stentof, 2019).

Case Based Learning (CBL)

Case-based learning is founded on similar theoretical principles about learning compared to PBL. Problems are seen as the starting point for the learning process, student collaboration is thought to improve learning, teaching is organized as facilitation and supervision, and students are required to take responsibility for their learning. 2019).

Therefore, it is not theoretical assumptions about learning that distinguish these methodologies, but the objectives and nature of the problems with which students learn. In contrast, learning objectives in the PBL case are typically defined much more narrowly, as in a specific organ system, or in a specific patient group, or in a specific pathology, for example. In this method, specific scenarios or user stories are created, such as "problem stimuli" carefully designed to ensure that students can achieve pre-specified learning objectives, in a structured way, usually assisted by a facilitator (Stentof, 2019).

Addressing other distinctions, such as between the PBL and the PBL case, several studies point to three main variables that differ between them: the objective of the problem, the time spent, and the evaluation. In the CBL case, the case materials developed by the professors delimit the spaces in which the students can locate the problems to be solved and, therefore, the objective of any case is to fully frame what the students will learn. The period for working on a case is often limited to one week and pre-defined steps are followed. Regarding assessment, working with cases offers students a unique experience to learn from peers while using previous experiences to build new knowledge. However, students by and large are not building towards a shared goal or written product (Stentoft, 2019).

Self-Directed Learning (SDL)

Self-directed learning is an initiative by the student to analyze the learning need, frame the learning objective, recognize resources, learn from others or from their materials, select and apply appropriate learning techniques and evaluate the results (Moustaffa, 2020)).

The skills acquired through SDL are gaining special importance in institutions of higher education, especially in faculties of medicine. In adapting to the cognitive explosion, in the age of technology and rapid change, to keep up with modernity and continuous development, and to improve the conditions of users, this method works on the student's abilities to plan and manage the activities of learning, to obtain knowledge and information, and to acquire specific skills, especially the ability to learn throughout life through self-learning (Moustaffa, 2020).

Team-Based Learning (TBL)

Team-based learning, as the name implies, is an approach that results in the use of most class time for teamwork. The main objective is to ensure that students can practice using course concepts, with some authors assuming that this methodology is like problem-based learning (Alnowaiser et al., 2019).

TBL strategy involves four basic principles: 1) groups must be properly formed and managed; 2) students must be held accountable for their learning; 3) team assignments should promote both team content and team development; and 4) students should receive frequent and immediate feedback (Alnowaiser et al., 2019).

TBL and PBL, despite having some similarities, some differences can also be pointed out, among which: PBL is student-centered and is applied without interaction with a large group, while TBL

requires this interaction and is centered on students. instructors: at TBL, students usually have the content information before the sessions, being asked to use this material to solve problems, working through applications (Alnowaiser et al., 2019).

Problem-Based Service Learning (PBS)

Problem-based service learning is a constructive pedagogical framework. Teachers introduce a problem to students in a real-world context so that students work through the complex problem and develop a clear solution or framework that would apply to the learning process. context (Hurt-Avila et al., 2021).

This methodology grew out of volunteerism and community service, emphasizing learning through community involvement. Within the practitioner-academic paradigm, students learn to apply research methodology and procedures in communities, providing an appropriate place to apply research-related educational content in a real-world practice environment (Hurt-Avila et al., 2021).

Considerations

It is interesting to note that, if, on the one hand, PBL aims to encourage students to seek solutions to the problems presented, on the other hand, students end up motivated to take more responsibility for their own learning than those involved in traditional teaching activities. Likewise, as teachers are seen not as sources of answers, but as facilitators of problem-solving, students tend to become more competent in the search for information. This method improves the teacher's work, as it encourages him to follow the research process developed by the students and the way in which they arrive at the solution to the problems they propose to solve. Thus, the PBL contributes to the development of continuous teacher training, as they are impelled to think of other ways to improve their pedagogical practice in the face of new learning challenges (Souza & Dourado, 2015).

Thus, working with real problems implies putting aside the idea that learning means memorizing transmitted concepts, but rather processing the information acquired through research, adding significant new understandings, for the expansion of the investigated knowledge. It also supposes abandoning the linear understanding of concepts to understand knowledge as a process in which several dimensions and variables are involved, which both teachers and students must take into account, such as: space, time, access to sources of information, investigation of the correct information, explained in an organized and well-argued way, in addition to putting into practice certain social skills, as well as the acquisition of skills such as shared communication, active listening and group organization (Souza & Dourado, 2015).

On the other hand, many authors propose carrying out more studies on PBL, to make it the main interactive learning strategy in higher education institutions. Among these proposals are, for example, discovering the factors that affect the development of different self-learning skills, what is the student's perception of this method to identify the most important characteristics, which obstacles can prevent the achievement of the desired objectives and try to understand the importance about changes in the educational process through it (Moustaffa, 2020; Roliak et al., 2021).

CO-CREATION

Definition

Co-creation is a learning technique that embraces the constructivist paradigm and exploratory approach, through a collaborative and reciprocal process in which all participants have the opportunity to contribute equally, although not necessarily in the same way, to the curricular or pedagogical conceptualization, decision-making, implementation, research or analysis (Bovill, 2020; Cook-Sather, 2020; Doyle & Buckley, 2020; Kaminskiene et al., 2020; European Commission, Directorate-General for Research and Innovation, 2021). The aim is to improve student active involvement, student experience, and the effectiveness of the learning environment (Martens, Meeuwissen, et al., 2019; European Commission, Directorate-General for Research and Innovation, 2021), making education a shared effort where learning and teaching are done with students and not for them (Doyle & Buckley, 2020; European Commission, Directorate-General for Research and Innovation, 2021).

Looking at the term specifically, both 'co' and 'creation' are significant. The 'co' stresses that the process is social, and the 'creation' that something new appears because of the process. The definitions presented imply that the concept has several important attributes, such as "to create, to work together (collaborative learning)", "to create something new together", "to obtain mutual value/benefit in a collaborative process (value co-creation)" and "to contribute equally (partnership)" (Eckhardt et al., 2021; Kaminskiene et al., 2020).

This methodology has attracted much attention over the past decade and has been discussed from multiple perspectives, including partnership learning communities, student-centred and person-centered learning, and personalized learning. All these mainly discuss the problem of learning ownership, co-creation, deeper student involvement in the process, and motivation (Bovill, 2020; Doyle et al., 2021; Kaminskiene et al., 2020; Longoria et al., 2021; Pearce et al., 2020; Skipper & Pepler, 2021). Likewise, co-creation can be achieved in several ways, examples include involving students in content assessment, teaching, and learning processes, conducting disciplinary research, or designing assignments, among others (Bovill, 2020; Doyle & Buckley, 2020). Thus, the concept becomes a definition of a border, which, despite being increasingly used in several areas, lacks clarity in its definition and inconsistent use of terminology (Kaminskiene et al., 2020; van Karnenbeek et al., 2020).

Regardless of this ambiguity, the authors agree that this method involves openness, respect, inspiration, support, security, closeness, and friendship, leading to innovation and mutual learning (Dollinger & Lodge, 2020a), and that conceptual analysis reflects the state of education. contemporary, when learning becomes a co-creative practice and is based on partnership and collaboration, changing the role of teachers and students, and occurring at different stages of curriculum implementation. This method can be successfully enhanced and supported by relevant and creative pedagogical strategies that include generative dialogue, negotiation, collaborative work, participatory design model, and others (Kaminskiene et al., 2020).

The existing literature is optimistic in evaluating co-creation as a teaching and learning tool at a conceptual level. However, there is limited evidence on the effectiveness of co-creation in terms of academic performance, as they observed that to prepare students for professional practice, it is essential to measure the effectiveness that these types of tasks present in terms of their learning. The appeal of this methodology as a pedagogical paradigm is explained by the wide range of benefits attributed to the existing literature, such as this growing interest. On the other hand, it is necessary to address the significant gaps that remain regarding knowledge of the effect of co-creation (Doyle et al., 2021; Doyle & Buckley, 2020).

Characteristics

Innovation efficiency and the ability to innovate are built on several factors: interaction, networks, partnerships, effective innovation practices, and the ability to combine perspectives and gather know-how from different entities. The creation of new industry-academy cooperation is one of the current objectives, aimed at supporting an innovation ecosystem and improving knowledge exchange. The question, in essence, is how to create policies, methodologies, and a culture of cooperation that impact the areas of innovation, the application of technology and research production and the creation of a better and more sustainable society (European Commission, Directorate- General for Research and Innovation, 2021).

A guided co-creation process aims to allow the emergence of interaction and the exchange of information and insights and, thus, create a whole new culture of innovation and cooperation. This methodology requires new skills, operating models, and methods, as well as intermediary organizations, to facilitate collaboration. Professional facilitation benefits all parties involved in the interaction and ensures the sustainability of initiatives. Intermediate organizations may understand academic and industrial viewpoints, and may act as liaison organizations, interfaces, or bridges. As the work progresses, the team must be willing to change its direction or point of focus if its findings, new information, or new insights demand it. The purpose of this type of work is not to provide conclusive or convincing evidence to elucidate the nature of the problem, but rather to help better understand the problem and its implications, providing answers to questions such as 'What if?', 'How could we?', 'Because?' and 'What could it be?' (European Commission, Directorate-General for Research and Innovation, 2021).

The creation of new knowledge derives from the application of research methods that are embedded in the delivery of a program or policy, through four collaborative processes: (1) co-ideation (generating an idea); (2) co-design (development of the program or policy and research methods); (3) co-implementation (implementing the program or policy in accordance with agreed research methods) and (4) co-evaluation (data collection, analysis, and interpretation). Comprising three fundamental principles (Pearce et al., 2020):

- Principle 1: new knowledge derives from the application of rigorous research methods;
- Principle 2: Research methods are incorporated into the delivery of a program or policy as a way of ensuring that new knowledge has an immediate practical application;
- Principle 3: co-creation comprises the four collaborative processes.

After analyzing the concept of co-creation, (Kaminskiene et al., 2020) pointed to a set of empirical indicators, which are used in the analysis of this method, of learning, grouped into the following categories:

1. Collaborative process: involving pedagogical process; level of interaction; active learning methods; negotiation elements;
2. Collaborative production: participatory design; collaborative analysis and communication; a phase in the knowledge appropriation model; collaboratively co-created curriculum;
3. Transformative interaction and teacher position: teacher as facilitator; teacher courage; teacher flexibility and improvisation;
4. Apprentice Agency: proactive role; students as evaluators of their experiences, as participants in decision-making processes, as partners and experts, and as co-researchers;

5. New learning space: different forms of specialization brought together; new learning platforms;

6. Author: increased cognitive development; critical analysis; applying theory to practice;

7. Learning community and learning partnership: empathy for employees; feeling of being respected;

8. Metacognitive practices: reflection; social practices;

9. Value co-creation: student property; authentic learning; greater responsibilities for students.

De Silva et al. (2021), despite the different forms and areas of co-creation projects analyzed in the literature, identified three types of determinants to consider before implementing this type of methodology: (a) the decision to engage in co-creation, (b) elements for co-creation offered by those involved, and (c) the management of co-creation. Thus, before creating a co-creation initiative, it is important to clarify the most important goals to be achieved, with the involvement of students and potentially other stakeholders (taking into account that decisions, when starting, include who to invite as participants), how many participants, in which phases the participants have certain responsibilities, the time of co-creation during the curriculum or later, and the duration of the co-creation (de Silva et al., 2021; Könings et al., 2021).

Although many authors agree that co-creation should be promoted, and despite a growing enthusiasm for this type of pedagogies, there are those who point to the need for further exploration of it (van Karnenbeek et al., 2020).

Higher education

Higher Education Institutions/Universities are understood as centers of excellence of competence, aimed at the dissemination of knowledge. In an increasingly global society, in which the strengthening of economic and social ecosystems is increasingly important, active learning methodologies are gaining more attention. This type of process encourages the sharing of ideas, points of view, insights, information, experiences, and knowledge, for the benefit of all parties involved (de Fátima Cruz et al., 2021; European Commission, Directorate-General for Research and Innovation, 2021).

Co-creation is based on an open innovation approach, where work involves multiple organizations (rather than a single organization) and often multiple knowledge and cultural domains. From a higher education perspective, collaboration with external organizations encourages the creation of new ideas, highlights research needs, and creates opportunities to initiate new studies to improve teaching practices, bring relevant content to teaching and create a foundation for the development of students' professional identities and employability (de Fátima Cruz et al., 2021; European Commission, Directorate-General for Research and Innovation, 2021).

As argued by Fátima Cruz et al. (2021), this type of collaboration between higher education and companies is based on three university missions: teaching, research, and engagement with society in its economic and social dimensions (innovation and technology transfer; continuing education; commitment as a link between university and society, in terms of teaching, research and social involvement).

Giner & Peralt Rillo (2016), demonstrate 3 important relationships established when using this type of method in higher education, these being:

- Co-creation and satisfaction: several authors emphasize the positive and direct relationship between co-creation and satisfaction;

- Satisfaction and loyalty: as a result of increased competition between educational institutions, many authors have focused on the study of student loyalty, with several highlighting the positive relationship between student satisfaction and loyalty;

- Co-creation and loyalty: several studies show the relationship between co-creation and loyalty.

There are several studies that refer to the relationship between co-creation, student satisfaction, and higher education, but Tarı Kasnakoğlu & Mercan (2020) argue that although co-creation can lead to satisfaction or that satisfaction is generated through co-creation, this must be understood as a process, not an end to solve the problem. That is, social and academic aspects of co-creation must be investigated, and it is the responsibility of teachers, students, and institutions alike to try to find ways to engage in the development of a mutually satisfying educational system. However, from a co-creation perspective, student satisfaction surveys are invalidated as tools for assessing overall excellence in education. It should be remembered that higher institutes/universities are the main authority figure responsible for starting to establish a functioning co-creation ecosystem.

In contrast, Könings et al. (2021) expose the two main challenges that institutions may face when implementing this method, namely: lack of support and lack of recognition. Institutions that do not support co-creation initiatives, that do not reserve dedicated time and that enable those involved to work on these initiatives, limit their implementation, and in these, time issues are related to difficulties in finding space for planning meetings, lack of time for extra work and review of previous education methods and materials, and limited time for lasting commitments and dialogue over time (needed to create a trusting context for the open exchange of ideas). Likewise, a lack of recognition or appreciation by traditional institutional structures hinders the implementation of co-creation. However, the same study sets out some standards that higher institutes/universities can use to try to tackle these challenges, such as providing support (through, for example, availability of time; space; small-scale tools and funding; a frequent and efficient two-way feedback and collaboration in reviewing course content and pedagogy, among others), investing in practical support from faculty (e.g. through the use of a specialist trainer who offers training sessions to develop the necessary skills and that serves as a kind of mentor, among others), and the establishment of a culture of recognition/valuation (such as, for example, ensuring those co-creation efforts are recognized, results and improvements are disseminated and shared in the community; that the student and faculty contributions are appreciated and rewarded; and explicitly invite students to speak and communicate in a way to get your feedback; between others).

Several authors indicate that to reap the potential benefits of this type of methodology in higher education, it is necessary to adopt a less ambiguous perspective, that actions are taken to make known all the activities that could potentially be developed, with a clear definition of objectives and a specific agenda to be covered with the next activity plans (de Fátima Cruz et al., 2021; Tarı Kasnakoğlu & Mercan, 2020; European Commission, Directorate-General for Research and Innovation, 2021).

Teacher/Student

To understand the ontology behind student-faculty partnerships and the co-creation of knowledge and quality assurance and promotion, it is important to explore all the roles of those involved, to ensure improvements in the quality of teaching and assessment of teamwork skills, with this type of active methodologies (Botha & Steyn, 2020).

Stressing that students and teachers must review their existing roles and relationships, respect each other's perspectives and skills, and ensure a psychologically safe environment for exchange, discussion, and collaboration, the existing literature points to the most varied approaches to facilitate processes of co-creation that are being implemented in different educational practices. It is the intentional collaboration between students, faculty, and potentially other stakeholders to improve education that creates a co-creation synergy (Könings et al., 2021).

In this method, the teacher becomes a facilitator. This is the person who sets the agenda and determines the activities needed to achieve the co-creation goals. He also guides the team through the process, guides group dynamics, and adjusts the flow as needed. The facilitator also helps the team to choose the right tools and methods, and in decision making strengthens innovative thinking, presents different perspectives, and asks the right questions. When co-creation activities are treated as a mechanism for interaction between different parties, the role of the facilitator, as an accelerator of the interaction, becomes significant. The central task of facilitation is to create an environment and opportunities for interaction and to activate and maintain interaction between the different parties (European Commission, Directorate-General for Research and Innovation, 2021).

Despite the increasing use of this type of method, the literature presents several challenges for teachers when using it. Feelings of letting go of control and insecurity may arise (co-creation requires teachers to redefine long-held assumptions about their role, responsibility, and power relations); scepticism that students may not add value (teachers may be sceptical about students' abilities to engage effectively in co-creation); the threat of openness to change (teachers need to be willing to reflect and continue to develop their skills); the traditional way of communicating with students no longer fits (in co-creation the goal is to unite different perspectives of stakeholders, but this implies finding a common ground); and the teacher's ability to contain anxiety (evidence indicates that courage is an essential quality for initiating and facilitating a co-creative process) (Kaminskiene et al., 2020; Könings et al., 2021).

To overcome these challenges, Könings et al. (2021) suggested the following strategies, which can be recommended in the co-creation process: building trust in co-creation with students; listening to students seriously; investing in training, reducing the power gap, developing shared responsibility, and improving the co-creation process.

One of the most important questions that arise is: "Why co-create with students?". Teachers are often hesitant to engage with students in collaborations or so-called "partnerships". However, Botha & Steyn (2020) argue that if engagement and relationships are built on shared trust, respect, reciprocity, and responsibility, the associated issues should not interfere with the development and enhancement of these partnerships. The same points out three main reasons why teachers should consider co-creating with students:

1. Students have a vision about teaching and learning that can make this practice more engaging, effective, and rigorous;

2. Faculty can draw on their insights, not only by gathering responses, but also by collaborating with them, to study and design teaching and learning together;

3. Partnerships between students and teachers change the understanding and capabilities of both, making them better.

The same study argues that, if education has existed, content creation has been considered a faculty responsibility. However, it argues that this should no longer be the case. The study points

to the need to involve students to help in the co-creation of content, it also proves that students enjoy the co-creation of content, if teachers involve them (Botha & Steyn, 2020).

According to the literature, students are the single driving force and, in the process, in general, they have the greatest influence on the success of this method, as they are the group with the most up-to-date knowledge and the group that will be future citizens, professionals, and leaders. (de Fátima Cruz et al., 2021; European Commission, Directorate-General for Research and Innovation, 2021).

Co-creation practices encourage the transformation of the student to become more than just a student. The matrix for them to become agents of change has four positions: a) students as evaluators of their experiences; b) students as participants in decision-making processes; c) students as partners, co-creators, and experts; d) students as agents of change. The authors also identify four roles that students usually assume in co-creation: (1) consultant; (2) co-researcher; (3) pedagogical co-designer; (4) representative (Bovill, 2020; Kaminskiene et al., 2020; Martens, Meeuwissen, et al., 2019).

In contrast, Könings et al. (2021) mentioned some challenges for the student in the co-creation process, such as the lack of process and experience in content (students are often not familiar with the co-creation process, which can make it difficult for them to understand the roles and provoke uncertainties), power relations (the hierarchical structure in education puts the student in a situation of imbalance, which can lead to personal risks resulting from the redefinition of roles and the teacher-student relationship), and voice fatigue (a phenomenon that has been reported to indicate students' reluctance to engage in co-creation).

To overcome these challenges, the same study presents four main strategies: motivating student involvement, ensuring speech safety, supporting students in developing necessary skills, and encouraging the fulfillment of their role as co-creators (Könings et al.., 2021).

The core of this methodology is undoubtedly the relationship between teachers and students, and as such, Könings et al. (2021) listed practice points that they should follow when co-creating:

- Through co-creation, teachers and students gain a better understanding of each other's perspectives on education. This can facilitate a more positive, inclusive, and democratic learning environment, greater internal motivation, and higher quality of educational design;

- To enable an open exchange of thoughts and ideas between students and teachers, it is important to ensure psychological safety, where power differences between them are diminished and trust is established;

- Teachers must genuinely listen to students and be open to implementing educational changes, through shared responsibility with students;

- Training them, especially in relation to feedback, can help improve the quality and effectiveness of two-way conversations;

- The student's degree of involvement must be aligned with their abilities, willingness to learn, involvement, and previous experiences;

- Connecting and sharing experiences promotes mutual learning, and faculty support, which can facilitate the co-creation process.

Implementation

Co-creation needs an ecosystem to function (Tarı Kasnakoğlu & Mercan, 2020). The literature points out three steps to consider when implementing this methodology (Botha & Steyn, 2020; de Silva et al., 2021; European Commission, Directorate-General for Research and Innovation, 2021):

- Co-creation preparation and team training: The unifying force of a co-creation team is a common interest and desire to work with a certain topic or theme. It motivates and involves the participants, influences the dynamics of the team, and gives relevance to the shared work. The desire to seek, discover and change the world is the best fuel for this type of work. The challenges for the teams are formed around phenomena relevant to business and society. During this process, diversity and different perspectives can be promoted through facilitation and teamwork methods, with the foundation always being laid in the team-building phase.

- Teamwork: This stage is the core of all co-creation activities. The starting point is the task given to the team, which is called the innovation challenge. Teamwork orientation, facilitation, and methods and tools support this exploratory approach.

- Valuing: Co-creation generates direct and immediate benefits for both parties, through results and interactions. In addition, the corporate culture created through projects and the interactions established between the main actors positively impact the innovation ecosystem. With active measures, the facilitator can influence the realization of benefits for different parties.

- Bearing these in mind, (Botha & Steyn, 2020) described the steps that must be followed in this journey that creates an opportunity for a partnership between teachers and students, to design and co-create a team capacity development resource, following a structured process:

- Training: establishing relationships, becoming familiar with the tasks, and creating rules of involvement;

- Storming: conflict of the internal group in the establishment of its structure;

- Sessions: start working in established roles through collaboration and support towards a common goal, where ideas and opinions are expressed openly, harmonizing team efforts;

- Closing: Provide an opportunity for evaluation of team members and recognize contributions made.

The European Commission report, Directorate-General for Research and Innovation (2021) points out some tips to follow so that this method works:

- Neutral facilitation: ensures the optimal operating environment necessary for genuine development;

- Motivated participation: the co-creation method works only when team members are motivated and have a personal incentive to participate;

- Maintain the agile co-creation process: this process should not be defined too precisely or in detail, it should provide a safe framework within which there is adequate space for the development of new ideas;

- Members of the same team: whether team members are seasoned industry experts or newcomers, create a balanced participation and allow all voices to be heard;

- Maintain an exploratory approach: co-creation should be a future-oriented exploration of an interesting theme, phenomenon or problem, and the desired outcome or solution should be left open and undefined at the beginning of the process;

- Students must be seen as future creators of change: students must be seen as representatives of their generation, future experts, and decision-makers with knowledge, values, and behaviors. Through this lens, they form their perspectives on future phenomena, which may be alternative, or even contradictory, to today's leaders;

- Involvement of experts: the participation of external experts is valuable if companies and co-creation teams have specific needs, issues or problems to solve;

- Take advantage of enthusiasm after the project: the recommendation is to start a conversation about greater cooperation immediately after the end of the co-creation process. At this point, new ideas are on the table and the inspiration created supports the spirit of collaboration.

Bringing co-creation ideas into practice can be a challenge (Könings et al., 2021). Some of these challenges are described in the literature, such as time constraints, the number of students, the change in organizational culture, distrust of the unknown learning method, the evaluation system, and the gaps between the theoretical practice of co-creation and the real practice. of the same in the classroom, the development of other types of capacities, the indirect commercialization of research results, and the difficulty of connectivity and awareness of the parties involved (Bovill, 2020; de Fátima Cruz et al., 2021; European Commission, Directorate-General for Research and Innovation, 2021):

However, Könings et al. (2021) highlight the importance that co-creation has in learning and teaching, describing that results can be expected at three levels, including the psychosocial learning environment (both students and teachers continually develop their skills and attitudes towards communication). , collaboration and dealing with conflict), motivation and metacognition (co-creation positively impacts satisfaction with education and, due to deeper engagement with concepts and themes, teaching and learning can be improved), and quality of educational design (by incorporating the expertise and perspectives of relevant stakeholders, co-creation can result in a more effective or attractive design of a course or curriculum). The same study presents three fundamental educational theories that can be used to deepen the understanding of the challenges and approaches, for the implementation of co-creation: the theory of self-determination (describes the three fundamental psychological needs that increase an individual's intrinsic motivation: autonomy, kinship, and competence), the positioning theory (states that people assume certain positions during interactions and that these are associated with rights and duties, and guide actions) and the theory of psychological safety (in the implementation of co-creation, stimulate a climate-safe for sharing thoughts and ideas among everyone is crucial).

Overall, the literature recognizes that co-creation is a powerful approach to improving educational interventions and outcomes, as seen by data suggesting a significant impact on academic performance (de Fátima Cruz et al., 2021; de Silva et al., 2021; Doyle et al., 2021; Doyle & Buckley, 2020; Sugino et al., 2016; Uskoković, 2018). But it also adds that co-creation does not completely replace the traditional methodology, being more a complementary interaction mechanism suitable to face challenges in all domains, and in the substantial difference between a co-creation project where a small group of selected students co-creates, and an approach of co-creation with an entire class where a teacher opens the learning and teaching experience following an active methodology (de Silva et al., 2021).

The study of co-creation processes has great value in identifying, more precisely how co-creation is created within a process of social innovation and how the elements of collaboration and co-

operation work. However, it is suggested that more research is needed, especially to identify the drivers and barriers of co-creation practices and their forms of institutionalization. Co-creation is a diverse and context-dependent phenomenon (Eckhardt et al., 2021).

Online

Co-creation activities can be developed in an online model through an educational platform. That is, universities must create a space to overcome the crisis, using the integration of resources between universities, professors, and students. Faced with the necessary closure of universities, they must mobilize different forms of education and online education resources, creating a place where stakeholders can interact and collaborate to co-create values, centered on the online education platform (Leem, 2021).

In the higher education online education platform, there should be interaction, knowledge sharing and equal access to information, based on the relationship between students and teachers that co-create values and, ultimately, improve student satisfaction and loyalty. Existing studies that emphasize that active participation in students' learning activities improves student satisfaction with learning are a concept that sees students as consumers. Therefore, co-production through interaction between students and teachers not only creates social capital but also increases trust. This high trust not only co-creates value but also increases learning satisfaction and loyalty. The co-creation process, using an online education platform, is where teachers and students work together to improve the student experience and strengthen the student's role as a partner. This can be explained as the process of integrating student and teacher resources to promote better activities and experiences. This led students to perceive the educational services provided by the online education platform as beneficial in several aspects, such as time, location, and experience. Thus, by forming intangible and intimate relationships with students, using the online education platform, they build satisfaction and loyalty towards the teacher and higher education. In the higher education environment, as in the general service sector environment, experience and personalization of educational services acquired through student-faculty relationships, based on online education platforms, improves student loyalty and satisfaction (Leem, 2021).

Assessment

While research and practice centered on students and academics working together to co-create in the higher education sector have increased, co-creation in assessment remains relatively rare in a higher education context (Doyle & Buckley, 2020).

The concept of "shared assessment or co-assessment" refers to student participation in the process in any of the different formats: self-assessment, peer assessment, and shared assessment (Doyle & Buckley, 2020).

The authors (Doyle & Buckley, 2020) clarify each of these concepts. The "peer review" can be carried out between groups, but also at an individual level within groups that share the same level, and should incorporate an element of critical reflection which, if deemed appropriate, can then lead to the actual classification of the work. On the other hand, "collaborative co-assessment/assessment" requires that students and teachers be involved together in the assessment and share responsibility for the assessment criteria, thus creating a true "participatory assessment". Consequently, the main differences between these two concepts refer to who is carrying out the assessment (students only or students and teachers together), and the degree of responsibility and participation that the parties have in the process. The concept of "shared evaluation" is applied

to the dialogue between the teacher and the student that takes place after an evaluation process by themselves or by peers, during which a joint decision is taken. This can be an individual or collective process, depending on the learning activity, process, or evidence being evaluated. All these concepts are used exclusively in relation to formative assessment processes.

Engaging students in a content generation has been promoted to foster in-depth teaching and increase student engagement, resulting in superior conceptual understanding. More specifically, the literature suggests a deeper understanding that can be realized when students are the authors of their questions and solutions. Through the question creation process, students must reflect on learning outcomes, critically evaluate questions according to their relevance and difficulty, fully understand the relevant material, and devise a comprehensive solution to support the correct answer. This is much more involved and cognitively demanding than just finding a solution. Several studies have been published that show how students consider that the use of training and shared or co-assessment systems have a positive influence on the development of professional skills and a statistically significant impact on academic performance (Doyle & Buckley, 2020; Hortigüela Alcalá et al., 2019). However, there is limited empirical evidence on its effectiveness in enhancing student learning (Doyle & Buckley, 2020).

Hortigüela Alcalá et al. (2019), for example, showed that significant improvements were observed in the analyzed competencies after carrying out training and shared processes or co-assessment, throughout the school year. Regarding the first factor, the perceptions of creative and autonomous work, these have increased significantly, demonstrating the impact of this type of assessment on the decision-making, involvement, and self-regulation of students. The second factor, related to interpersonal and intrapersonal skills, the results obtained were considered especially relevant, since the acquisition of collaborative skills and the management of group responsibilities are those that are most closely related to the search for a job in the world. current. The third factor, associated with reflective and critical communication skills, can be explained by two fundamental reasons: (a) the diversity of assessment procedures and instruments used; (b) the range of feedback channels and ways of recording the knowledge achieved. The fourth group of skills in which students noticed significant improvements were metacognitive skills (e.g. organization and planning), with university students who experience shared training or co-evaluation being more aware of what they learn and have a greater ability to organize and plan their tasks, indicating that the purposes for which the assessment was designed to have been fulfilled. On the other hand, the same study points to the continuity of the analysis of proposals and innovative approaches to evaluation based on the transversality of knowledge, as this represents the true determining factor in the delivery of successful social and professional development.

Advantages and disadvantages

In much of the literature on partnership and co-creation, evidenced outcomes are linked across the wide range of different approaches taken (Bovill, 2020). As advantages, it points to a greater and better teaching and learning experience, a better quality of teaching, the alignment of curriculum plans with market needs, greater student motivation, an increase in student involvement, the development of transversal skills and abilities, the formation of professional networks and an improved reputation of the institution (Botha & Steyn, 2020; de Fátima Cruz et al., 2021; Doyle et al., 2021; Doyle & Buckley, 2020; European Commission, 2020; Directorate-General for Research and Innovation, 2021). The following are highlighted (Bovill, 2020; Ribes-Giner et al., 2016):

- Improved inclusion: Offering the opportunity to co-create does not guarantee full participation and inclusion. At this point, the question of who participates - as well as who is excluded and who is excluded, being that what is important is equal opportunities to participate, but also the opportunity not to participate - is natural for students to participate in different ways. To be inclusive, teachers need to ensure that all opportunities for participation are genuinely open to all and that the methods used to discuss and enact co-creation are clear, appeal to a diversity of learners, offer different ways to engage, to suit the strengths of different students and be aware of different socio-economic and cultural backgrounds. It is easier to appeal to encourage all students to participate in some way where there is an expectation that the whole class is working together towards a shared purpose that has been negotiated.

- Building positive relationships: Greater student-faculty interaction in and out of class can lead to greater academic success and performance, greater educational aspirations, personal and intellectual development, student satisfaction and motivation. Positive relationships between student and teacher are at the heart of co-created learning and teaching, thus being a key point for this type of methodology, but also for achieving positive results in its implementation.

- Communicative participation: educational services involve students, teachers, and staff in this participation, allowing students to play an active role in different interactions. This student-centered approach, giving them a protagonist participation, allows for achieving satisfactory results in "pedagogical and business results". Another advantage of this relationship is student control, improved program adaptation and learning flexibility. In addition, it was observed that when the student collaborates with the teacher, satisfaction levels increase positively, and knowledge and skills are also improved.

- Satisfaction: this approach allows institutions to offer a valuable and different learning experience, which enables student involvement, increasing student and faculty satisfaction, and allows them to exceed their expectations, promoting satisfaction and loyalty. Higher levels of satisfaction lead to increased revenue, reduced costs, and continuing education.

The existing literature is optimistic about co-creation becoming a teaching and learning tool at the conceptual level. However, there is limited evidence of its effectiveness in terms of academic performance, and some disadvantages are indicated, such as the acceptance and difficulty of changing the nature of the power dynamics and relationship between professors and students that both are already used to, the adherence of students (taking into account the assessment component), the different ethical elements (for example, the creation of differentiated groups between a class - those who co-create and those who choose not to do so), and the change in the way in which teaching and learning are having significant implications for the support offered to teachers and the evolution of learning (Bovill, 2020; de Fátima Cruz et al., 2021; Doyle et al., 2021; Doyle & Buckley, 2020).

This type of methodology thus allows the operationalization of collaborative activities at different levels that involve the sharing of knowledge, skills and experience, and the integration of resources and capabilities. When these constructions are supported by dialogue, transparency between all parties involved and inherent proactive interaction, a teaching environment for co-creation is created, not as a service that is sold, but as an added value with synergistic effect for students, teachers, companies, and society in general. It is evident that for this whole process to occur, facilitating elements are necessary and barriers must be overcome (de Fátima Cruz et al., 2021).

Frameworks

Teaching the concept of co-creation and active teaching methodologies to university students came to be considered valuable, due to the demand of companies and public sectors that turn to new techniques as inspiration to develop innovations and services. However, as previously mentioned, the literature points to several models followed, so through the research carried out in this article, we arrived at 35 models that are presented as Supplementary material (Download), considering their description, strengths, and limitations.

Other concepts

Various approaches and models have been introduced to develop more student-centered modes of teaching and learning (Valtonen et al., 2021). There is enormous variation in the types of co-creation that are being implemented (Bovill, 2020), and students are increasingly involved in the design of educational practices, which is reflected in the growing body of educational literature on these types of approaches. As a result, concepts such as design-based research, participatory design (design thinking), flip model, and value co-creation (Martens, Meeuwissen, et al., 2019) emerge. One of the challenges raised by this diversity is ensuring clarity about the nature of the work being described, researched, and discussed (Bovill, 2020; Martens, Meeuwissen, et al., 2019).

Design Based Search (DBR)

DBR is a collaboration between researchers and education professionals, in which they develop answers to educational problems and advance theoretical understanding. The design of the learning environment is formed by educational theories. This aims to improve the design of the learning environment, as well as to develop and refine educational theories (Martens, Meeuwissen, et al., 2019).

In addition to researchers and education professionals, other stakeholders may be involved in the iterative design process, such as students and educational designers. However, the role of students is often limited to providing information/data, and these are not presented as central actors within the design process (Martens, Meeuwissen, et al., 2019).

The benefits include improving educational practice and theory, testing and refining educational design guidelines on what could work, under what conditions, and why (Martens, Meeuwissen, et al., 2019).

Participatory Design (PD)

A term closely related to co-creation is participatory design or design thinking, which also refers to collaboration with all stakeholders in the design of education. While co-creation primarily aims at positive effects of engagement for students directly integrated into it, PD primarily focuses on improving the quality of educational innovations, ensuring the use and utility of educational design for faculty and students (Könings et al., 2021; Martens, Meeuwissen, et al., 2019).

Educate, train and work as a team in various strategic and operational areas to start incorporating design thinking into your change processes, ensuring that the student's voice is a constant: not just redirecting and validating hypotheses, problem definitions and generating solutions, but acting as a form of verification of meaning in institutional initiatives. This saturation of practice within the organization builds the team's ability to run their co-creation workshops with students, as

well as providing a quick and low-cost way to assess convenience and feasibility. Thus, by using tools that elevate and engage with the student experience, institutions can better design interactions that are relevant, timely, and feel personalized at scale, to create conditions for student success, in an educational environment that values, listen and empower the life. (Mann, 2020).

From this collaboration comes the implementation of new tailor-made educational projects, which is its greatest benefit. It is an approach that has been central to advising practice in other contexts and should continue to inform how we include, value, respect, and teach students for the future. The terms that are linked here are collaborative design, student voice, participation, and involvement (Martens, Meeuwissen, et al., 2019).

The same authors (Martens, Meeuwissen, et al., 2019) discuss the overlap between these terms. The similarity between DBR, PD, and co-creation lies in valuing the contribution of students as actors in the educational design process. However, in trying to differentiate the terms, the main differences lie in the level of student participation in the design process and in the focus on educational theory. Students as central actors increase from DBR to co-creation, while the focus on educational theory decreases. Therefore, it is important that their level of participation is aligned with the purpose of the approach.

Flip Model

It is based on the active involvement of students in searching, discovering, selecting, and assembling knowledge from diverse sources of literature into learning material for the classroom. As students actively co-create the content together with other students and the teacher, the model thus arises from a branch of co-creation and is also designated as co-creational (Uskoković, 2018).

Whereas in the traditional model students are introduced to the content during the lesson and are asked to deepen understanding afterward, in this model, they are introduced to the content beforehand and understanding of the content is set to occur during the lesson, through a variety of individual or group learning activities. The number of objects students are exposed to before class is versatile and can include instructional videos, textbook chapters, professional papers, clinical case reports, or other materials. Shifting the focus from content delivery to content comprehension, the idea of the flip is built on cognitive theory centered on the idea that each subject constructs a perceptual reality for itself (Uskoković, 2018).

The flip teaching model is being increasingly adopted by higher education institutions as an active learning alternative to traditional lectures. However, it presents several critical premises that still need to be further explored and analyzed (Uskoković, 2018).

Value Co-creation

Co-creation can be broadly described as a process of creation in which different stakeholders, collaboratively and reciprocally, contribute to the creation of value. In this new approach to value co-creation, value emerges through the integration of resources, which arise not only from the supplier but also from the other parties involved in the co-creation process. According to this perspective, the value incorporated in the educational offer is essentially co-created through a complex network of stakeholders that interact with universities, implying the need for the active participation of the different stakeholders in the process of planning, configuring, and delivering the educational offer (de Fátima Cruz et al., 2021).

From a service point of view, students of higher education institutions can be considered customers, and the value of education is therefore determined by them. In addition, students work

as co-creators of value; in other words, while teachers must provide effective content, students must perform appropriate learning behaviors (Sugino et al., 2016). Sugino et al. (2016) described this process as follows:

1. First, the teacher develops an assumption about the learning outcomes for the students. Learning outcomes are seen as desirable state changes for students.

2. In this step, the teacher identifies what constitutes the valuable state for the students, designs educational content, and suggests it. Here, the teacher needs to reach a consensus with the students about the educational content and the learning outcome.

3. After consensus, the teacher provides the educational content and performs a formative assessment to improve this content.

4. Finally, a general assessment is carried out.

To co-create value in higher education, a student needs to play the role of co-creator of value and co-create value with a teacher. Therefore, the student needs to acquire, improve and use his ability to co-create value (Sugino et al., 2016).

Thus, value co-creation can be defined in the light of service marketing theory, considering two dimensions: co-production and value in use. However, this approach still needs to be investigated further in the context of higher education (Lin et al., 2020).

CONSIDERATIONS

Co-creation activities produce a very effective new type of thinking and culture of innovation. This method forces the parties to work in an exploratory way, giving an entirely new experience and expanding their understanding of how innovation can be achieved (European Commission, Directorate-General for Research and Innovation, 2021).

It can be argued that co-creation activities bring the parties together and reduce their functional and mental distance. When the co-creation activity becomes continuous, it allows the emergence of a new type of culture of cooperation, and creates and strengthens cooperative relationships at the base level, enabling the effective use of other forms of knowledge exchange. Therefore, the co-creation activity should be seen primarily as a tool to increase long-term interaction, and the performance of activities should not be measured by immediate indicators of innovation, such as the number of ideas generated. This means that co-creation projects cannot be based on predefined performance or output goals, but must remain an inspiring journey of discovery (European Commission, Directorate-General for Research and Innovation, 2021).

Co-creative research and knowledge mobilization depend on trust, respect, and security. Trust arises through positive and open relationships. If people don't trust each other then they are unlikely to share their ideas, give feedback, and be open to true collaboration. To build this trust, it is helpful to trust the interdependent self, which is less focused on influencing others, and more on truly understanding the opinions and experiences of others. Respect is also vital for co-creation, as both faculty and students bring knowledge to the table, and respect for different domains of knowledge and experience is vital. If they are not able to respect these different visions, then co-creation will not be possible. Only when you really trust and respect each other will there be security to openly discuss and develop projects that are truly co-creative and interdependent (Skipper & Pepler, 2021).

The importance of focusing on the management of higher education lies in the fact that these institutions are an example for the whole community, through activities and sustainable policy development. According to the results obtained in study 43, co-creation is an easy-to-use and well-adapted tool, and it provides a suitable environment for the collaboration of different participants (Longoria et al., 2021).

Accordingly, the (European Commission, Directorate-General for Research and Innovation, 2021) demonstrated that all five teams that participated in this methodology completed the process in the given time and within the planned scope. The results obtained, both in terms of student and company satisfaction, as well as in terms of team interaction and teamwork, from the discovery phase to the creation phase, in terms of the level of enthusiasm about the dynamics and team motivation, and in terms of student confidence, were positive. Thus, this method is considered a significant new tool in the business development portfolio, and as a builder of interaction with the academic environment. The same study validated that the development of personal skills during the co-creation project is significant. These include creativity, collaboration, entrepreneurship, and critical thinking skills. The results show that students became more aware of their competence level and understood the competence requirements during the project work period.

Van Karnenbeek et al. (2020) reflect on the dynamics of community knowledge illustrated in the potential for multidirectional flows of types of knowledge, in this type of methodology. Not all learning communities exchange knowledge (and learn) in the same way or at the same time. Although the transfer of student knowledge was encouraged and its importance recognized, student knowledge was considered of lesser value. There was no transfer of knowledge to the other parties involved. Thus, this observation questions the reciprocity of knowledge exchanges in this pedagogy.

Although co-creation is presented as an alternative model for translating research, its use in teaching is hampered by its conceptual immaturity. Evidence of a lack of consistency in its definition is seen in the wide variability of terms used to describe this active methodology. In this way, the literature points to the need for more studies on this, to arrive at a standardized terminology that will help in future theoretical development and tests where these processes are used and clearly defined (Pearce et al., 2020)

CONCLUSION AND FUTURE RESEARCH

It is known that teaching and learning are dynamic and complex practices, in which a single method does not produce the expected results in learning for professional practice. The rapid development of scientific and technological knowledge, and the changes and alterations in economic, social, political, and environmental systems demand from professionals, in the most different areas, a multidimensional vision of the reality in which they are inserted. In this sense, the educational process needs to advance in the introduction of innovative teaching and learning methods that accompany the evolution of knowledge in the training of professionals who know how to transfer theoretical knowledge to practice. The theme that gave rise to this review and its starting question: what does the literature review about active methodologies in higher education?

In the course of this work, it was confirmed that active learning methodologies such as PBL and co-creation are presented as innovative learning methods used in different educational institutions of the most different levels and have achieved important results in the learning and development of professional skills. As they are models that are neither fixed nor closed, they

can be adapted to the different realities and needs of the courses and study contents. Another important issue to note is the recent interest in the development of non-cognitive skills, which has increased considerably to fluctuate relevant educational policies. The literature has indicated that students' success in meeting their personal needs, in their professional lives, and in meeting the requirements of the labor market does not depend only on cognitive skills. On the contrary, success also depends on non-cognitive skills. In this way, one cannot fail to recognize that the gains that make active methodologies into effective methods, whether in higher education or at other levels of education, translate the benefits arising from their ability to achieve broader educational goals than those achieved by traditional teaching methodologies. In addition to the production of knowledge, the development of skills and attitudes, students can thus be successful in their academic and professional careers.

From the analysis of 31 models of co-creation, it can be concluded that there are still several views on this subject and its borders, which are based on the lack of clarity and uniformity of the same. To bring together all the applied models of this active methodology, the models mentioned in this study were analyzed according to their development base, strengths, and weaknesses. Despite their differences, all of them were directly or indirectly focused on the "three innovations": creativity, innovation, and entrepreneurship, in order to explore a new path to cultivate students' innovative skills, considering three vertices: students, teachers, and professionals, who learn together as they co-create. It is not only effective operating guidance for cultivating students' innovation capacity that is important, but also an ecosystem of cyclical and interactive co-creation in colleges and universities that can be built to link the integration of industry and education with innovation. of design. In this way, the most important thing during this process is to provide an authentic and meaningful approach to the development of competencies, for the future working lives of the students.

This research opened many possibilities for further investigation. The analysis of the various active methodologies presents in higher education, such as the exposition of the various models followed by co-creation and the analysis of Demola serve as a basis for the contribution of clarity, understanding, and application of these methods.

Although this was an extensive investigation on the subject, this study has limitations such as the divergence and variation of the various articles within the different types and forms of methodologies, especially in the various models followed, which made the process in the research methodology difficult.

This work highlights the need for universities to generate and support the implementation of this type of teaching/learning methodologies in these institutions. It is hoped that this research will help in the future to develop a general and a model that can be followed and implemented, so that this type of methods can be scaled and equitable.

REFERENCES

Allert, C., Dellkvist, H., Hjelm, M., & Andersson, E. K. (2022). Nursing students' experiences of applying problem-based learning to train the core competence teamwork and collaboration: An interview study. Nursing Open, 9(1), 569–577. https://doi.org/10.1002/nop2.1098

Alnowaiser, H. M., Alwehaibi, M., & Mekkawy, M. (2019). Pharmaceutical sciences the effect of combining team based learning (tbl) and problem--based learning (pbl) upon the students' perception toward problem based learning at college of dentistry, qassim university: A cross sectional study. 03, 5825–5833. http://www.iajps.com

Androutsos, A., & Brinia, V. (2019). Developing and piloting a pedagogy for teaching innovation, collaboration, and co-creation in secondary education based on design thinking, digital transformation, and entrepreneurship. Education Sciences, 9(2). https://doi.org/10.3390/educsci9020113

Baldwin, L. P. (2017). Editorial. In Active Learning in Higher Education (Vol. 18, Issue 1, pp. 3–10). SAGE Publications Ltd. https://doi.org/10.1177/1469787417704286

Botha, A. J. M., & Steyn, A. A. (2020). Student-faculty partnership in design: Evaluating a co-creation practice and sharing of findings within the South African higher education context. South African Journal of Higher Education, 35(4). https://doi.org/10.20853/34-5-4270

Bovill, C. (2020). Co-creation in learning and teaching: the case for a whole-class approach in higher education. Higher Education, 79(6), 1023–1037. https://doi.org/10.1007/s10734-019-00453-w

Catalá-Pérez, D., Rask, M., & de-Miguel-Molina, M. (2020). The Demola model as a public policy tool boosting collaboration in innovation: A comparative study between Finland and Spain. Technology in Society, 63. https://doi.org/10.1016/j.techsoc.2020.101358

Cavanagh, A., Vanstone, M., & Ritz, S. (2019). Problems of problem-based learning: Towards transformative critical pedagogy in medical education. Perspectives on Medical Education, 8(1), 38–42. https://doi.org/10.1007/s40037-018-0489-7

Chammas, G., Kayed, S., al Shami, A., Kays, W., Citton, M., Kalot, M., al Marj, E., Fakhr, M., Yehya, N. A., Talhouk, S. N., Al-Hindi, M., Zein-El-Dine, S., Tamim, H., Lakkis, I., Abou Najm, M., & Saliba, N. A. (2020). Transdisciplinary interventions for environmental sustainability. Waste Management, 107, 159–171. https://doi.org/10.1016/j.wasman.2020.03.043

Chang, H. C., Wang, N. Y., Ko, W. R., Yu, Y. T., Lin, L. Y., & Tsai, H. F. (2017). The effectiveness of clinical problem-based learning model of medico-jurisprudence education on general law knowledge for Obstetrics/Gynecological interns. Taiwanese Journal of Obstetrics and Gynecology, 56(3), 325–330. https://doi.org/10.1016/j.tjog.2017.04.011

Compton, R. M., Owilli, A. O., Norlin, E. E., & Hubbard Murdoch, N. L. (2020). Does problem-based learning in Nursing Education Empower Learning? In Nurse Education in Practice (Vol. 44). Elsevier Ltd. https://doi.org/10.1016/j.nepr.2020.102752

Cook-Sather, A. (2020). Respecting voices: how the co-creation of teaching and learning can support academic staff, underrepresented students, and equitable practices. Higher Education, 79(5), 885–901. https://doi.org/10.1007/s10734-019-00445-w

de Fátima Cruz, M., Franco, M., & Rodrigues, M. (2021). Exploring university–firm collaboration in teaching: A case study of co-creation. Industry and Higher Education. https://doi.org/10.1177/09504222211049347

de Silva, M., Gokhberg, L., Meissner, D., & Russo, M. (2021). Addressing societal challenges through the simultaneous generation of social and business values: A conceptual framework for science-based co-creation. Technovation, 104. https://doi.org/10.1016/j.technovation.2021.102268

Dollinger, M., & Lodge, J. (2020a). Understanding value in the student experience through student–staff partnerships. Higher Education Research and Development, 39(5), 940–952. https://doi.org/10.1080/07294360.2019.1695751

Dollinger, M., & Lodge, J. (2020b). Student-staff co-creation in higher education: an evidence-informed model to support future design and implementation. Journal of Higher Education Policy and Management, 42(5), 532–546. https://doi.org/10.1080/1360080X.2019.1663681

Doyle, E., & Buckley, P. (2020). The impact of co-creation: an analysis of the effectiveness of student authored multiple choice questions on achievement of learning outcomes. Interactive Learning Environments. https://doi.org/10.1080/10494820.2020.1777166

Doyle, E., Buckley, P., & McCarthy, B. (2021). The impact of content co-creation on academic achievement. Assessment and Evaluation in Higher Education, 46(3), 494–507. https://doi.org/10.1080/02602938.2020.1782832

Dreyer, E., Barahona, P., Chávez, B. (2021). Estudiantes Pragmáticos, Teóricos y Educación Superior Mediante Metodologías Activas Pragmatists, Theorists' Students and Tertiary Education Through Active Methodologies. . Int. J. Odontostomat., 15(1), 152-158. http://dx.doi.org/10.4067/S0718-381X2021000100152

Eckhardt, J., Kaletka, C., Krüger, D., Maldonado-Mariscal, K., & Schulz, A. C. (2021). Ecosystems of Co-Creation. In Frontiers in Sociology (Vol. 6). Frontiers Media S.A. https://doi.org/10.3389/fsoc.2021.642289

Eikebrokk, T. R., Garmann-Johnsen, N. F., & Olsen, D. H. (2021). Co-creation in networks of SMEs: A conceptual model of the cocreation process. Procedia Computer Science, 181, 360–366. https://doi.org/10.1016/j.procs.2021.01.179

Fitriana, N., Widayanti, F. D., & Firmanto, B. (2021). Problem Base Learning Virtually In Blended Learning Model for Chemistry Lessons During The Covid-19 Pandemic. JURNAL PENDIDIKAN SAINS (JPS), 9(1), 14. https://doi.org/10.26714/jps.9.1.2021.14-25

Geissdoerfer, M., Bocken, N. M. P., & Hultink, E. J. (2016). Design thinking to enhance the sustainable business modelling process – A workshop based on a value mapping process. Journal of Cleaner Production, 135, 1218–1232. https://doi.org/10.1016/j.jclepro.2016.07.020

Geissdoerfer, M., Savaget, P., & Evans, S. (2017). The Cambridge Business Model Innovation Process. Procedia Manufacturing, 8, 262–269. https://doi.org/10.1016/j.promfg.2017.02.033

Ghani, A. S. A., Rahim, A. F. A., Yusoff, M. S. B., & Hadie, S. N. H. (2021). Effective Learning Behavior in Problem-Based Learning: a Scoping Review. In Medical Science Educator (Vol. 31, Issue 3, pp. 1199–1211). Springer. https://doi.org/10.1007/s40670-021-01292-0

Giner, G. R., & Peralt Rillo, A. (2016). Structural equation modeling of co-creation and its influence on the student's satisfaction and loyalty towards university. Journal of Computational and Applied Mathematics, 291, 257–263. https://doi.org/10.1016/j.cam.2015.02.044

Gonçalves, M. F., Gonçalves, A. M., & Gonçalves, I. M. F. (2020). Aprendizagem baseada em problemas: uma abordagem no ensino superior na área da saúde. Práticas Educativas, Memórias e Oralidades - Rev. Pemo, 2(1). https://doi.org/10.47149/pemo.v2i1.3676

Han-Yu, W., Sheng-Hwa, T., & Peng, M. Y. P. (2018). The impact of professors' Transformational Leadership on University Students' employability development based on social cognitive career theory. ACM International Conference Proceeding Series, 54–58. https://doi.org/10.1145/3206129.3239422

Hemker, L., Prescher, C., & Narciss, S. (2017). Design and evaluation of a problem-based learning environment for teacher training. Interdisciplinary Journal of Problem-Based Learning, 11(2). https://doi.org/10.7771/1541-5015.1676

Hortigüela Alcalá, D., Palacios Picos, A., & López Pastor, V. (2019). The impact of formative and shared or co-assessment on the acquisition of transversal competences in higher education. Assessment and Evaluation in Higher Education, 44(6), 933–945. https://doi.org/10.1080/02602938.2018.1530341

Hurt-Avila, K. M., DeDiego, A. C., & Starr, J. (2021). Teaching Counseling Research and Program Evaluation through Problem-Based Service Learning. Journal of Creativity in Mental Health. https://doi.org/10.1080/15401383.2021.1936329

Ibrahim, M., & Al-Shahrani, A. (2018). Implementing of a problem-based learning strategy in a Saudi medical school: requisites and challenges. International Journal of Medical Education, 9, 83–85. https://doi.org/10.5116/ijme.5aae.2db8

Ikudayisi, A. E., Chan, A. P. C., Darko, A., & Adegun, O. B. (2022). Integrated design process of green building projects: A review towards assessment metrics and conceptual framework. In Journal of Building Engineering (Vol. 50). Elsevier Ltd. https://doi.org/10.1016/j.jobe.2022.104180

Ilbine, J., Charlotte, J., Koning, D., Crul, M., & Wever, R. (2016). Models of co-creation_2016. https://www.researchgate.net/publication/303541138

OECD (2016), Innovating Education and Educating for Innovation: The Power of Digital Technologies and Skills, OECD Publishing, Paris. http://dx.doi.org/10.1787/9789264265097-en

Jacobi, J., Llanque, A., Mukhovi, S. M., Birachi, E., von Groote, P., Eschen, R., Hil ber-Schöb, I., Kiba, D. I., Frossard, E., & Robledo-Abad, C. (2022). Transdisciplinary co-creation increases the utilization of knowledge from sustainable development research. Environmental Science and Policy, 129, 107–115. https://doi.org/10.1016/j.envsci.2021.12.017

Juuso, E. K. (2018). An advanced teaching scheme for integrating problem-based learning in control education. Open Engineering, 8(1), 41–49. https://doi.org/10.1515/eng-2018-0006

Kaminskiene, L., Žydžiunaite, V., Jurgile, V., & Ponomarenko, T. (2020). Co-creation of learning: A concept analysis. European Journal of Contemporary Education, 9(2), 337–349. https://doi.org/10.13187/ejced.2020.2.337

Ketonen-Oksi, S., & Valkokari, K. (2019). Technology Innovation Management Review Innovation Ecosystems as Structures for Value Co-Creation.

Khatiban, M., Falahan, S. N., Amini, R., Farahanchi, A., & Soltanian, A. (2019). Lecture-based versus problem-based learning in ethics education among nursing students. Nursing Ethics, 26(6), 1753–1764. https://doi.org/10.1177/0969733018767246

Kibret, S., Teshome, D., Fenta, E., Hunie, M., Taye, M. G., Fentie, Y., & Tamire, T. (2021). Medical and health science students' perception towards a problem-based learning method: A case of debre tabor university. Advances in Medical Education and Practice, 12, 781–786. https://doi.org/10.2147/AMEP.S316905

Könings, K. D., Mordang, S., Smeenk, F., Stassen, L., & Ramani, S. (2021). Learner involvement in the co-creation of teaching and learning: AMEE Guide No. 138. Medical Teacher, 43(8), 924–936. https://doi.org/10.1080/0142159X.2020.1838464

Konstantinidis, E. I., Petsani, D., & Bamidis, P. D. (2021). Teaching university students co-creation and living lab methodologies through experiential learning activities and preparing them for RRI. Health Informatics Journal, 27(1). https://doi.org/10.1177/1460458221991204

Kusnandar, K., van Kooten, O., & Brazier, F. M. (2019). Empowering through reflection: participatory design of change in agricultural chains in Indonesia by local stakeholders. Cogent Food and Agriculture, 5(1). https://doi.org/10.1080/23311932.2019.1608685

Lazo-Porras, M., Perez-Leon, S., Cardenas, M. K., Pesantes, M. A., Miranda, J. J., Suggs, L. S., Chappuis, F., Perel, P., & Beran, D. (2020). Lessons learned about co-creation: developing a complex intervention in rural Peru. Global Health Action, 13(1). https://doi.org/10.1080/16549716.2020.1754016

Leask, C. F., Sandlund, M., Skelton, D. A., Altenburg, T. M., Cardon, G., Chinapaw, M. J. M., de Bourdeaudhuij, I., Verloigne, M., & Chastin, S. F. M. (2019). Framework, principles and recommendations for utilising participatory methodologies in the co-creation and evaluation of public health interventions. Research Involvement and Engagement, 5(1). https://doi.org/10.1186/s40900-018-0136-9

Leem, B. (2021). An effect of value co-creation on student benefits in COVID-19 pandemic. International Journal of Engineering Business Management, 13, 184797902110583. https://doi.org/10.1177/18479790211058320

Lin, L., Huang, Z., Othman, B., & Luo, Y. (2020). Let's make it better: An updated model interpreting international student satisfaction in China based on PLS-SEM approach. PLoS ONE, 15(7 July). https://doi.org/10.1371/journal.pone.0233546

Liu, L., Du, X., Zhang, Z., & Zhou, J. (2019). Effect of problem-based learning in pharmacology education: A meta-analysis. In Studies in Educational Evaluation (Vol. 60, pp. 43–58). Elsevier Ltd. https://doi.org/10.1016/j.stueduc.2018.11.004

Longoria, L. C., López-Forniés, I., Sáenz, D. C., & Sierra-Pérez, J. (2021). Promoting sustainable consumption in Higher Education Institutions through integrative co-creative processes involving relevant stakeholders. Sustainable Production and Consumption, 28, 445–458. https://doi.org/10.1016/j.spc.2021.06.009

Mann, C. (2020). Advising by Design: Co-creating Advising Services With Students for Their Success. Frontiers in Education, 5. https://doi.org/10.3389/feduc.2020.00099

Martens, S. E., Meeuwissen, S. N. E., Dolmans, D. H. J. M., Bovill, C., & Könings, K. D. (2019). Student participation in the design of learning and teaching: Disentangling the terminology and approaches. Medical Teacher, 41(10), 1203–1205. https://doi.org/10.1080/0142159X.2019.1615610

Martens, S. E., Spruijt, A., Wolfhagen, I. H. A. P., Whittingham, J. R. D., & Dolmans, D. H. J. M. (2019). A students' take on student–staff partnerships: experiences and preferences. Assessment and Evaluation in Higher Education, 44(6), 910–919. https://doi.org/10.1080/02602938.2018.1546374

Martens, S. E., Wolfhagen, I. H. A. P., Whittingham, J. R. D., & Dolmans, D. H. J. M. (2020). Mind the gap: Teachers' conceptions of student-staff partnership and its potential to enhance educational quality. Medical Teacher, 42(5), 529–535. https://doi.org/10.1080/0142159X.2019.1708874

McKenzie, B., & Brown, A. (2017). Exploring a Problem-Based Learning Approach in Pharmaceutics. Pharmacy, 5(3), 53. https://doi.org/10.3390/pharmacy5030053

Meina, W., Fan, W., Kaining, M., & Yang, L. (2021). A Probe into Cultivation Path of Students' Ability in Innovative Digital Technology Design Based on Design Thinking. E3S Web of Conferences, 236. https://doi.org/10.1051/e3sconf/202123605075

Menezes-Rodrigues, F. S., Errante, P. R., Lima, R. Y., Carmo, A. De O. Do, Silva, E. F., Gehrke, F., Carvalho, D. S., Tikazawa, E. H., Ferraz, R. R. N., Caricati-Neto, A., & Taha, M. O. (2019). Vantagens da utilização do Método de Aprendizagem Baseada em Problemas (MAPB) em cursos de graduação na área da saúde. Revista Ibero-Americana de Estudos Em Educação, 14(2), 340–353. https://doi.org/10.21723/riaee.v14i2.11660

Merisier, S., Larue, C., & Boyer, L. (2018). How does questioning influence nursing students' clinical reasoning in problem-based learning? A scoping review. In Nurse Education Today (Vol. 65, pp. 108–115). Churchill Livingstone. https://doi.org/10.1016/j.nedt.2018.03.006

Morad, S., Ragonis, N., & Barak, M. (2021). An integrative conceptual model of innovation and innovative thinking based on a synthesis of a literature review. Thinking Skills and Creativity, 40. https://doi.org/10.1016/j.tsc.2021.100824

Moreno-serna, J., Sánchez-chaparro, T., Stott, L., Mazorra, J., Carrasco-gallego, R., & Mataix, C. (2021). Feedback loops and facilitation: Catalyzing transformational multi-stakeholder refugee response partnerships. Sustainability (Switzerland), 13(21). https://doi.org/10.3390/su132111705

Morgado, M., Mendes, J. J., & Proença, L. (2021). Online problem-based learning in clinical dental education: Students' self-perception and motivation. Healthcare (Switzerland), 9(4). https://doi.org/10.3390/healthcare9040420

Moustaffa, N. A. (2020). Self-Learning Skills and Problem-Based Learning in Medical Education: Case Study. Revista Amazonia Investiga, 9(30), 50–59. https://doi.org/10.34069/ai/2020.30.06.5

Nagarajan, S., & Overton, T. (2019). Promoting Systems Thinking Using Project- And Problem--Based Learning. Journal of Chemical Education, 2901–2909. https://doi.org/10.1021/acs.jchemed.9b00358

Narvaez Caballero, N., & Gélvez García, L. E. (2020). Propuesta metodológica para el desarrollo del pensamiento creativo desde el diseño de la ingeniería concurrente. Sophia, 16(2), 207–218. https://doi.org/10.18634/sophiaj.16v.2i.976

Newsom, L., Proctor, R., Marshall, L. L., & Liao, T. V. (2019). Implementation and evaluation of problem-based video podcasts in an introductory pharmacokinetics course. Currents in Pharmacy Teaching and Learning, 11(12), 1213–1220. https://doi.org/10.1016/j.cptl.2019.09.003

Pearce, T., Maple, M., Shakeshaft, A., Wayland, S., & McKay, K. (2020). What is the co-creation of new knowledge? A content analysis and proposed definition for health interventions. International Journal of Environmental Research and Public Health, 17(7). https://doi.org/10.3390/ijerph17072229

Pezaro, S., Jenkins, M., & Bollard, M. (2022). Defining 'research inspired teaching' and introducing a research inspired online/offline teaching (riot) framework for fostering it using a co-creation approach. Nurse Education Today, 108. https://doi.org/10.1016/j.nedt.2021.105163

Ribes-Giner, G., Perello-Marín, M. R., & Díaz, O. P. (2016). Co-creation Impacts on Student Behavior. Procedia - Social and Behavioral Sciences, 228, 72–77. https://doi.org/10.1016/j.sbspro.2016.07.011

Roliak, A., Dutka, H., Mylytsya, K., Matiienko, O., & Oliinyk, N. (2021). Problem-based Learning in Pedagogic Tertiary Education: European Context Through Denmark Environment. Independent Journal of Management & Production, 12(3), s071–s084. https://doi.org/10.14807/ijmp.v12i3.1521

Santos, A. B. A. dos, Bianchi, C. G., & Borini, F. M. (2018). Open Innovation and Cocreation in the Development of New Products: the role of design thinking. International Journal of Innovation, 6(2), 112–123. https://doi.org/10.5585/iji.v6i2.203

Sari, Y. I., Sumarmi, Utomo, D. H., & Astina, I. K. (2021). The Effect of Problem Based Learning on Problem Solving and Scientific Writing Skills. International Journal of Instruction, 14(2), 11–26. https://doi.org/10.29333/iji.2021.1422a

Senabre Hidalgo, E., & Fuster Morell, M. (2019). Co-designed strategic planning and agile project management in academia: case study of an action research group. Palgrave Communications, 5(1). https://doi.org/10.1057/s41599-019-0364-0

Skipper, Y., & Pepler, D. J. (2021). Knowledge mobilization: Stepping into interdependent and relational space using co-creation. Action Research, 19(3), 588–605. https://doi.org/10.1177/1476750320960810

Souza, S. C. de, & Dourado, L. (2015). APRENDIZAGEM BASEADA EM PROBLEMAS (ABP): UM MÉTODO DE APRENDIZAGEM INOVADOR PARA O ENSINO EDUCATIVO. HOLOS, 5, 182. https://doi.org/10.15628/holos.2015.2880

Sriphong, L. (2019). Innovative problem-based learning integrated with G suite for education. PervasiveHealth: Pervasive Computing Technologies for Healthcare, 163–167. https://doi.org/10.1145/3306500.3306546

Stentoft, D. (2019). Problem-based projects in medical education: extending PBL practices and broadening learning perspectives. Advances in Health Sciences Education, 24(5), 959–969. https://doi.org/10.1007/s10459-019-09917-1

Sugino, R., Mizoguchi, S., Kimita, K., Muramatsu, K., Matsui, T., & Shimomura, Y. (2016). A method for consensus building between teachers and learners in higher education through co-design process. Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), 9735, 197–208. https://doi.org/10.1007/978-3-319-40397-7_20

Swanson, E., McCulley, L. v., Osman, D. J., Scammacca Lewis, N., & Solis, M. (2019). The effect of team-based learning on content knowledge: A meta-analysis. Active Learning in Higher Education, 20(1), 39–50. https://doi.org/10.1177/1469787417731201

Tarı Kasnakoğlu, B., & Mercan, H. (2020). Co-creating positive outcomes in higher education: are students ready for co-creation? Journal of Marketing for Higher Education. https://doi.org/10.1080/08841241.2020.1825031

European Commission, Directorate-General for Research and Innovation. (2021). Testing the feasibility of a new industry-academia knowledge exchange concept focusing on companies' needs : final report, Publications Office of the European Union.

Tzu, S., & Philosopher, C. (n.d.). Rapid Product Development in University-Industry Collaboration:

Uskoković, V. (2018). Flipping the flipped: the co-creational classroom. Research and Practice in Technology Enhanced Learning, 13(1). https://doi.org/10.1186/s41039-018-0077-9

Valtonen, T., Leppänen, U., Hyypiä, M., Kokko, A., Manninen, J., Vartiainen, H., Sointu, E., & Hirsto, L. (2021). Learning environments preferred by university students: a shift toward informal and flexible learning environments. Learning Environments Research, 24(3), 371–388. https://doi.org/10.1007/s10984-020-09339-6

van Karnenbeek, L., Janssen-Jansen, L., & Peel, D. (2020). Conceptualising Co-creative Planning Pedagogies: The Community Knowledge Triangle. Planning Practice and Research. https://doi.org/10.1080/02697459.2020.1856501

Wulandari, F. E., & Shofiyah, N. (2018). Problem-based learning: Effects on student's scientific reasoning skills in science. Journal of Physics: Conference Series, 1006(1). https://doi.org/10.1088/1742-6596/1006/1/012029

Zambrano Guerrero, C. A., & Rodríguez Pabón, D. M. (2021). Design thinking como herramienta para prevenir la violencia basada en género en estudiantes universitarios. Revista Guillermo de Ockham, 19(2), 293–306. https://doi.org/10.21500/22563202.5316

Zurbriggen, C., & Lago, M. G. (2019). An experimental evaluation tool for the Public Innovation Lab of the Uruguayan government. Evidence and Policy, 15(3), 437–451. https://doi.org/10.1332/174426419X15537488717501