INSTRUCTIONAL DESIGN MODELS FOR IMMERSIVE VIRTUAL REALITY - A SYSTEMATIC LITERATURE REVIEW

Maria Castelhano
Universidade do Porto & Universidade Aberta
Porto, Portugal
up202210803@up.pt

Leonel Morgado
Universidade Aberta & INESC TEC
Coimbra, Portugal
leonel.morgado@uab.pt

Daniela Pedrosa
Instituto Politécnico de Santarém & CIDTFF
Santarém, Portugal
daniela.pedrosa@ese.ipsantarem.pt

***Abstract*—The emergence of accessible virtual reality headsets in the past decade multiplied educational uses of immersive virtual reality. Higher education, in particular, has seen many such reports emerge. However, there are scarce frameworks for higher education professionals to plan and deploy immersive virtual reality within their pedagogical practice. To attain a perspective on this field, we conducted a systematic literature review using SCOPUS search, focusing on Instructional Design Models for Immersive Virtual Reality in online Higher Education. This review aimed to provide a comprehensive overview of these models, their respective phases, and distinctive characteristics. The review identified two categories of Instructional Design Models for Immersive Virtual Reality in Higher Education: 1) Models specific to such contexts, with aspects such as managing immersion time or providing prior contact with the immersive environment; 2) Models developed for other contexts and adapted to immersive virtual reality, addressing aspects such as the importance of creating objectives, assessment elements, or defining resource purpose. We conclude that current instructional models used for immersive virtual reality in higher education lack the combination of the overall pedagogical concerns with the specific ones for immersive virtual reality. Thus, we recommend further research to develop instruction models that combine both aspects of learning design concerns.**

Keywords—instructional models, instructional frameworks, immersive virtual reality, VR, online higher education

I. INTRODUCTION

Virtual Reality (VR) has reemerged in the last decade, given availability of powerful and cost-effective headsets, as a promising technology for enhancing pedagogical practices in higher education. With its spatially immersive and interactive nature, headset-based VR (henceforth, "immersive VR") offers unique opportunities for creating engaging and effective learning experiences. However, to effectively employ immersive VR in pedagogical practice, one needs well-designed instructional models, aligned with principles of instructional design and educational technology standards.

In this paper, we present a systematic review and comparison of instructional design models for immersive VR in higher education. We aim to identify existing instructional design models specifically tailored for VR-based instruction, analyze their phases and characteristics, and compare them based on the standards set by the Association for Educational Communication and Technology. Furthermore, we conduct content analysis to identify adaptations and recommendations proposed by these models to use of immersive VR as a teaching tool.

II. THEORETICAL BACKGROUND

The technological evolution of society has been an integral part of transformations in education, through the inclusion of technologies in the teaching and learning process [1], [2]. With the evolution of technology, new formats of education have emerged, based on immersive learning environments [3], driven by advances in technologies such as real-time graphics, haptic input-output devices, motion sensors, and augmented reality (AR) [4]. These immersive environments are where two complex phenomena co-occur: learning and immersion [3]. Immersion overall refers to a state of deep cognitive or physical involvement or absorption in a narrative, an activity or an experience. In the context of learning, immersion can help students focus and engage more deeply with the learning material, leading to improved retention and understanding of the content [3]. In parallel, digital literacy has emerged as a crucial skill set for individuals to live, learn, and work effectively in digital environments [5]. This includes the ability to assess the relevance and purpose of digital information, communication skills in digital environments, skills to create multimedia content, programming, the ability to adopt security and sustainability measures in data protection, and the ability to solve problems and adapt digital resources for different purposes [6]. In addition to these new concepts, new challenges have also arisen, and concepts emerged to address them, such as instructional design. Instructional design has the primary objective of enabling and ensuring the quality of instruction, making it more efficient, effective, and less challenging. It can be described as the process that supports needs analysis, definition of learning objectives, and establishment of evaluative goals and specific outcomes for successful learning. It involves establishing connections between learning theories and the practice of instructional system development [7]–[10]. Together, this interconnection, structuring, and planning of instruction can assist educators in preparing for meaningful learning experiences. Instructional design models typically consist of common elements such as planning, implementation, and evaluation [11]. According to the Association for Educational Communications & Technology, Instructional Design should follow as guidelines 10 Standards for Distance Learning: (1) Purpose; (2) Assumptions; (3) Sequence; (4) Activities; (5) Resources; (6) Application; (7) Assessment; (8) Reflection; (9) Independent Learning; (10) Evaluation. Purpose is the articulation between the goals and objectives and the collaboration between the structure and the student. Assumptions is the consideration of students' prior learning and their ability to employ the technology/tools used in the course. Sequence is the path of learning, affecting the efficient acquisition of knowledge. Activities deal with adaptations to

the defined content and learning objectives. Resources deal with the adaptation for technological accessibility. Application is concerned with providing opportunities to apply new learning. Assessment, both continuous and formative, is about including feedback. Reflection is intended to deepen the learning experience. Independent Learning is about including opportunities for feedback, review, and reflection. And finally, Evaluation is about being goal-oriented and grounded on the acquisition of new knowledge, understanding, and skills, and also on the instructor's self-assessment, and on students' self-assessment [12], [13].

In the context of VR, these concepts must consider that it is evolving towards a fully immersive synthetic spatial reality, where the user can experience a completely realistic simulation of a virtual environment. This involves the use of advanced technologies such as motion tracking devices, brain interfaces, and haptic feedback [4], [14]. VR is typically described as a computer graphics technology [15] that allows the user to socially or individually interact in a synthetic environment [14], [15] that provides believable experiences. A technical goal of VR is to completely make the user feel present inside the computer-generated world, giving the impression of having "stepped inside" the synthetic world. VR has been used in K-12 and higher education as a pedagogical tool [19], as well as in various other contexts [16], [17]. Over the years, this technology has been expanding and consolidating in diverse fields of application [14], [15], [18]. This may be due to its technological improvement, but also to the possibilities it offers for better apprehension of the contents by the students and in its ability to enable practical applications, offering the opportunity to learn by doing [14]. In Higher Education, specifically, this technology has been widely used as a teaching resource [15]. Sample areas: a) Health Sciences, for example for representation of organs or acquisition of manual skills: chemistry labs; anatomy atlas; dental morphology, and more; b) Engineering, e.g.: building design and planning; virtual engineering laboratories; simulation of engineering techniques; and 3) Humanities, e.g: (1) Second language learning in context; (2) Historical sites tours [19]. Those uses have been varied, such as to introduce students to (1) procedural-practical knowledge (filling out a report or extinguishing fires); (2) for declarative knowledge (learning names of planets or theoretical concepts in pneumatics); (3) and for developing analytical and problem-solving skills (diagnosing patients or learning to code) [14].

Enabling this potential in a widespread manner, for the worldwide community of instructors and learners, requires elements of instructional design, to ensure the practicality and quality of instruction. It is described as the art of creating detailed specifications that allow the development, evaluation, and maintenance of learning situations [19]–[21], supporting needs analysis, goal setting, evaluative goal setting, and specific learning outcomes, [7]–[9], [19], [21], [22]. Instructional design is thus of great importance because it is through this that instructors develop guidance on how to develop and optimize the learning process in a feasible, quality-based approach [23], [24].

III. METHODOLOGY

To identify the guidance available on effectively implementing Immersive Virtual Reality in Online Higher Education pedagogy, we set to identify models of Instructional Design that have been applied with this educational technology context. A systematic review [25] was conducted to identify such, along with their phases and characteristics. The systematic review protocol, in view of application to educational sciences and computer science, follows Kitchemham et al. [25], which is commonly used in this field. It has seven elements: (1) Objective; (2) PICOC (Population, Intervention, Comparison, Outcome, Context); (3) Research questions; (4) Keywords and Synonyms; (5) Search String; (6) Source; and (7) Selection Criteria.

A. *Objective*

We aim to identify instructional design models for immersive virtual reality environments in online higher education with their phases and characteristics.

B. *PICOC (Population, Intervention, Comparison Outcome, Context)*

TABLE I. PICOC

PICOC	
Population	Students or instructors in degree-granting programs.
Intervention	Instructional design with immersive VR
Comparison	Characteristics of the immersive VR instructional models
Outcome	Instructional design models for VR
Context	Online Higher Education

C. *Research questions*

- What are the instructional design models for immersive virtual reality?
- What phases do instructional design models contemplate?
- What are the characteristics of the immersive instructional design models?

D. *Keywords and Synonyms*

TABLE II. PICOC

Keyword	**Synonyms**
Instructional models	Learning design models, instructional design, instructional frameworks, pedagogical design, pedagogical frameworks, pedagogical models
Online degree-granting courses	Distance learning, University, e-learning, online learning
Immersion	VR, immersive, virtual reality

E. *Search String*

("Online degree courses" OR "Distance learning" OR "University" OR "e-learning" OR "online learning") AND ("immersion" OR "VR" OR "immersive" OR "virtual reality") AND ("Instructional models" OR "Learning design models" OR "instructional design" OR "instructional frameworks" OR "pedagogical design" OR "pedagogical frameworks" OR "pedagogical models").

F. *Source*

The selected database was Scopus (http://www.scopus.com) for its expressiveness at an international level and its self-worth at an academic level.

G. Selection Criteria

Inclusion Criteria:

- Instructional models description for the application of Virtual reality in online higher education.

Exclusion Criteria:

- Application of immersive virtual reality without instructional model description.
- Augmented reality, not virtual reality.
- Language the research team is not proficient with.
- Not applied in Online Higher Education.
- Not spatially immersive virtual reality (non-headset).
- No mention of an instructional design model.
- The full version of the paper is not available.
- Not applied in classes using immersive virtual reality.

A total of 197 studies were retrieved from the Scopus database. Nine were duplicates. The remaining 188 studies were selected by title, abstract and short read according to the eligibility criteria (presented in the Selection Criteria section). After screening, 170 studies were excluded for various reasons – mostly for not being with immersive virtual reality. The remaining 18 publications underwent a full-text evaluation, with only 4 articles having reached the extraction phase. The process is presented in the flowchart (Fig.1.).

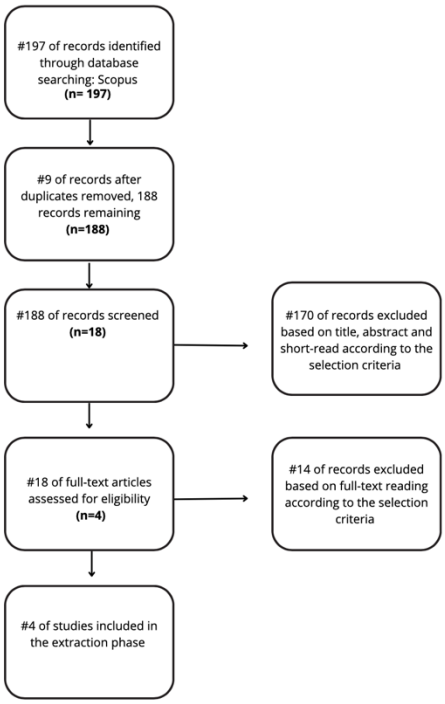

Fig. 1. Flow of literature search

From the final articles corpus, it is noticeable that the largest group of exclusion was of articles that were not based on using immersive VR headsets (126 exclusions). This was followed by publications that were in the context of Online Higher Education (16 exclusions).

For Data Extraction, we followed these extraction questions:

- RQ1 Which instructional design model for immersive VR is used in the paper?
- RQ2 Which instructional design models for immersive VR are mentioned in the background section of the paper?
- RQ3 Which phases of instructional design models for immersive VR are mentioned in the article's background section?
- RQ4 Which phases of instructional design models for immersive VR is used in the paper?
- RQ5 What are the characteristics of the model? What theoretical concepts is it based on?

For the data analysis, a content analysis was carried out that focused on two main parts: the definition of the characteristics of the models aimed at verifying the context of the model's emergence and whether it was based on other models previously developed for other contexts, and the phases, i.e. all the elements that described the steps that the authors used in the conception of Instructional Design, as well as suggestions and guidelines.

Those elements were used to analyze the identified VR Instructional Design models regarding the standards of the Association for Educational Communications & Technology [12], [13]. This analysis enabled us to identify eventual qualitative gaps in those Instructional Design Models for Immersive Virtual Reality.

IV. RESULTS

For data analysis, thematic content analysis was carried out. Four Instructional Design models for Immersive Virtual Reality were identified from the survey process: (1) XR ABC Framework [26]; (2) iVR Learning (M-iVR-L) Framework [27]; (3) TESLA Instructional Design Model [24]; (4) Castronovo et al. Design Model [28]. In this section, these models are summarized using the descriptive framework, including their characteristics and phases.

H. XR ABC Framework by Shippee and Lubinsky (2021) [26]

Characteristics of the model:

XR ABC Framework provides a common approach and language for designing, developing, and describing learning experiences to the use of VR.

Phases of the instructional design model:

Absorb: This stage involves an absorbing experience. In this stage it is expected the use of several immersive tools with the objective of sustaining experiences of comprehension and recollection.

Blend: In this stage, with the use of pre-existing resources for VR, it is expected to instill in the student new ways of learning, with the objective of taking them to apply, analyze and evaluate the content.

Create: In this stage learning moments and experiences arise that allow the creation of new content. This aims to demonstrate understanding of the content by building unique objects that did not previously exist within VR applications.

This stage allows learners to use creativity to demonstrate actual learning and understanding. Learners become owners of the learning and creators of content.

I. iVR Learning (M-iVR-L) Framework by Mulders, Buchner and Kerres (2020) [27]

Characteristics of the model:

Based on the Cognitive Theory of Multimedia Learning, a framework was developed with six recommendations support the learning process with Immersive Virtual Reality.

Phases of the instructional design model:

Learning first, immersion second: It is recommended to manage the use of immersive resources to prioritize the learning process over immersion. Immersion (here considered only in a spatial sense, not in a cognitive absorption sense) is used only as much as necessary to achieve learning objectives.

Segment complex tasks into smaller units: It is recommended to segment the content into different sessions to avoid overloading the students and to aid learning management and acquisition.

Provide learning relevant interactions: It is recommended to avoid unnecessary interactions that are irrelevant to learning; allow for pre-training of students, not only in terms of basic concepts but also on how to use the interactive tools.

Guide immersive learning: It is recommended to invest in guidance during use of Immersive Virtual Reality, to provide moments of learning acquisition without the increased load provided by the tool becoming an impediment to it.

Build on existing knowledge: It is recommended to use prior knowledge of the student to introduce new concepts and tools such as VR. This strategy will allow management of learning difficulty and verification of the students' level of knowledge and the support they need.

Provide constructive learning activities: It is recommended to provide constructive learning activities that allow the knowledge of learning to be built and applied to new problem-based tasks, inside or outside of Immersive VR.

J. TESLA Instructional Design Model by Fragkaki, Hatzligeroydis, Palkova and Kovas (2019) [24]

Characteristics of the model:

This model was based on three other Instructional Design models. The ASSURE model took the role of the base model. The TPACK model was integrated in the fourth step of the ASSURE model [Utilize Technology and Resources] and the Kirkpatrick model was integrated in the last step of the ASSURE model [Analyzing and Evaluating].

Phases of the instructional design model:

TESLA ASSURE

Analyze Learners: In this stage of the model, the authors focus on distinguishing and knowing the needs, knowledge, skills, and attitudes of the learners.

State Standards and Objectives: Defining the goals to be achieved by the learners with instruction.

Select Strategies, Technology and Resources: Selecting the strategies, technology, and resources.

Use Technology and Resources: Plan how resources will be used in a way that contributes to the acquisition of the goals. In this planning phase the TPACK model was inserted as an additional element of critical thinking. This model is described in three primary forms of knowledge: Content Knowledge, Pedagogical Knowledge, and Technological Knowledge. Based on the application scenario described in the article, Content Knowledge focuses on students' perceived knowledge about the topic of VR learning scenarios; Technological Knowledge concerns knowledge about specific ways of thinking and acting with VR, tools, and resources; and Pedagogical Knowledge concerns students' in-depth knowledge of the theoretical, conceptual, and methodological framework that pedagogically supports VR content. This general type of knowledge applies to understanding why learners learn, what they learn, and how they can use it. It is about learner learning, general classroom management skills, lesson planning, and types of student assessment.

Require Learner Participation: Plan how to actively involve learners.

Evaluate and Revise: In this step the evaluation of the teaching-learning process is prioritized. This includes training strategies and the technology, media and materials used. To support this, they selected the Kirkpatrick model. This model contains four levels, the first relating to evaluation of student reaction or satisfaction; the second level relating to evaluation of learning, understanding how students have acquired the knowledge or skills; the third level is behavioral assessment, in which changes in behavior are verified; and the fourth levels is outcome assessment, to determine whether the learning objectives have been met.

K. Castronovo et al. Design Model (2019) [28].

Characteristics of the model:

The model by Castronovo et al. is based on the ADDIE Instructional Design model.

Phases of the instructional design model:

Analysis: In this phase the target audience and the context are first identified. In a second moment the learning objectives are defined.

Design: Definition of the components to be used in the instruction. Definition of the components of game creation: mechanics, story, technology, and aesthetics.

Development: Putting into practice the created elements and the defined learning objectives. Creation of the game.

Implementation and evaluation: The phases of implementation and evaluation were not described in the application of the model to the context.

V. ANALYSIS

Based on the Association for Educational Communications & Technology [12], [13] standards verification of their presence in the Instructional Design models for Immersive Virtual Reality studies was performed.

L. XR ABC Framework

XR ABC Framework model described by three steps [Absorb; Blend; Create], is limited in its description. One only finds reference to the standard Assumptions through the reference in the Absorb stage to recollection moments to take into account previous learning and students' previous

knowledge; to the Activities and Resources standards, in the Blend stage with the introduction of different tools with the aim of broadening experiences; and finally the application proposed in the Create stage in which the student is given the opportunity to create their own resources.

M. iVR Learning (M-iVR-L) Framework

The iVR Learning (M-iVR-L) Framework presents itself as a set of recommendations that aim to play a relevant role in the design of an instructional plan, especially in the context of the scarce presence of guiding elements.

It is possible to find reference to resources in the recommendations for "Learning first, immersion second", in which emphasis is given to the management of the use of immersive resources to prioritize the learning process over immersion; and in the recommendation "Provide learning relevant interactions" in which importance is given to the pre-training of students, not only in terms of basic concepts but also on how to use the interactive tools.

As for the standardization of activities, this is visible in the recommendation to "Segment complex tasks into smaller units", in which importance is given in this context to dividing tasks to lessen the students' overload and to aid the management and acquisition of learning.

Promotion of orientation also has great prominence in the recommendation "Guide immersive learning", in the sense of helping the student in the environment and in the management of learning in this context, in which the load is higher. In addition, the Assumption standard also has recommendations for connecting to prior learning. This is found in the recommendation to "Build on existing knowledge."

In these recommendations, one finds references to the standard application in the recommendation "Provide constructive learning activities" which recommends carrying out constructive learning activities that allow the construction of the knowledge of learning and its application to new tasks based on problems, inside or outside the Immersive VR, to enhance the opportunity to apply learning.

N. TESLA Instructional Design Model

The TESLA model is a composition of three models, starting with the ASSURE model, promoting a cross-linking of data and the reinforcement of components such as reflection and critical thinking through the TPACK model, and assessment through the Kirkpatrick model.

The ASSURE model focus on standards as the purpose through the Analyze Learners and State Standards and Objectives, which promote the establishment of goals and objectives, as well as the study of learners and their relationship with the content; the standard of the resources in which there is a focus on Selecting strategies, technology, and resources, as well as planning how the resources will be used to contribute to the acquisition of the objectives. In this same section, Use Technology and Resources, the TPACK model is introduced, which in addition to introducing elements of critical reflection that relate to the reflection standard, introduces relevance to technological knowledge that concerns knowledge about specific ways of thinking and acting, in this case with VR.

Finally, evaluation standard are the "Evaluate and Revise" step with the introduction of Kirkpatrick's evaluation model.

O. Castronovo et al. Design Model

Castronovo et al Design Model is presented as an approach to using the ADDIE Instructional Design model for teaching in Immersive Virtual Reality. In the case presented, only three of the five steps of the model were applied.

In this contextual application of the model, it is only possible to verify the presence of the purpose with the use of the students' analysis and the structuring of the objectives; the resources with the design and structuring of the materials to be used in learning; and the application in the development when putting the activities into practice.

VI. DISCUSSION

It was noticeable that considering the standards of the Association for Educational Communications & Technology, none of the models under study addressed all of them. Standards such as continuous/formative assessment, that is, the promotion of feedback, the sequencing of activities, the use of independent learning, and how to promote assessment, all are gaps in the studied models. Among those, it is perceptible that the recommendations proposed in the iVR Learning (M-iVR-L) Framework are the most descriptive and specific to the context under study: instruction in Virtual Reality. Their recommendations address issues such as the need to segment the classes, to provide guides throughout the sessions, and the previous introduction to the tool, among others for better reflection on the context and to help in the preparation of the classes.

The use of models not originally developed for the context under study proved to be vague regarding their examples and the needs faced when planning classes for immersive Virtual Reality, as is the case of Castronovo et al. Design Model.

On the other hand, from the models studied it is possible to observe that two distinct groups emerges as to the recommendations they present. On the one hand, the XR ABC Framework and the iVR Learning (M-iVR-L) Framework, especially the latter, introduce contextual elements of the application of Virtual Reality in teaching, such as the need for segmentation of sessions to avoid overload, prior exploration of the tool given the experimentation of different resources, the promotion of follow-up moments among others. On the other hand, the application of traditional models created for another context allows reflection about the importance in these same contexts, of clearly defining the objectives considering the target audience, of planning, and of structuring how the resource will be used in what context and for what purpose, of selecting strategies and of outlining an evaluation plan.

VII. CONCLUSIONS

This systematic review sought to identify instructional models used in online higher education with immersive learning environments based on virtual reality headsets, such as Oculus, HTC, or others. We identified four models of instructional design for immersive Virtual Reality and analyzed them, finding that they are based on Instructional Design models developed for other contexts, especially traditional models such as ADDIE.

Of the four models, two groups stand out: those that present suggestions for the VR context and were developed specifically for the VR context; and those that were applied to the VR context but had been developed in a generic instructional design context. The XR ABC Framework and the

iVR Learning (M-iVR-L) Framework comprise the former group, presenting recommendations related to the use of VR: segmenting tasks, managing immersion time, and providing pre-instruction contact experiences with the tool. The latter group consists of the TESLA model and the Castronovo el al. model. Being more generic, they recall the importance of creating objectives directed to the target audience, considering the elements of evaluation, and defining the use of the resources and the purpose, among other aspects.

The iVR Learning Framework (M-iVR-L) Framework stands out as the most complete supporting element for the design of classes in Virtual Reality. But even so, it does not include all the standards of the Association for Educational Communications & Technology [13], [14] (AECT). It does present relevant elements about the context that allow a reflection on the elements to be considered when preparing a session for Immersive Virtual Reality, such as the need for task segmentation due to the increased load resulting from the use of the tool.

Thus, future research seeking to develop instructional models for VR may consider setting forth from M-iVR-L to address all standards of AECT, but also to combine the aspects of learning design concerns that more generic models have kept and are less present in current VR-specific models.

ACKNOWLEDGMENT

This work was funded by the European Commission, under project REVEALING – REalisation of Virtual rEAlity LearnING environments (VRLEs) for Higher Education – Erasmus+ / Cooperation Partnerships 2021-1-DE01-KA220-HED-000032098. We also extend our thanks to all collaborators and partners involved.

D. Pedrosa expresses gratitude to the Foundation for Science and Technology (FCT) and CIDTFF for their support under the Scientific Employment Stimulus 2017, within the framework of project CEECIND/00986/2017, as well as project UID/CED/00194/2020.

REFERENCES

[1] A. Gutiérrez-Martín and K. Tyner, "Educación para los medios, alfabetización mediática y competencia digital," *Comunicar: Revista Científica de Comunicación y Educación*, vol. 19, no. 38, pp. 31–39, 2012, doi: 10.3916/C38-2012-02-03.

[2] J. Ferrés and A. Piscitelli, "La competencia mediática: propuesta articulada de dimensiones e indicadores," *Comunicar: Revista Científica de Comunicación y Educación*, vol. 19, no. 38, pp. 75–82, 2012, doi: 10.3916/C38-2012-02-08.

[3] L. Morgado, "Ambientes de aprendizagem imersivos," *Immersive learning environments*, pp. 102–116, Dec. 2022, doi: 10.18817/vjshr.v1i2.32.

[4] W. Chen, "Collaboration in Multi-user Immersive Virtual Environment," phdthesis, Université Paris Saclay (COmUE), 2015. Accessed: Apr. 14, 2023. [Online]. Available: https://theses.hal.science/tel-01340364

[5] P. Reddy, B. Sharma, and K. Chaudhary, "Digital Literacy: A Review of Literature," *IJT*, vol. 11, no. 2, pp. 65–94, Jul. 2020, doi: 10.4018/IJT.20200701.oa1.

[6] A. Ferrari, "DIGCOMP: A Framework for Developing and Understanding Digital Competence in Europe.," JRC Publications Repository. Accessed: Mar. 30, 2022. [Online]. Available: https://publications.jrc.ec.europa.eu/repository/handle/JRC83167

[7] M. R. Hanifa and H. B. Santoso, "Evaluation and recommendations for the instructional design and user interface design of coursera MOOC platform," in *2019 International Conference on Advanced Computer Science and information Systems (ICACSIS)*, IEEE, 2019, pp. 417–424.

[8] M. Molenda, C. M. Reigeluth, and L. M. Nelson, "Instructional Design," in *Encyclopedia of Cognitive Science*, L. Nadel, Ed., Nature Publishing Group, 2003.

[9] G. R. Morrison, S. M. Ross, J. E. Kemp, and H. Kalman, "Designing Effective Instruction John Wiley & Sons," *Inc., United States*, 2011.

[10] V.-V. I. G. KL, "Paradigms in the theory and practice of education and training design," *Educational Technology Research and Development*, vol. 52, no. 2, p. 69, 2004.

[11] W. Dick, "The Dick and Carey Model: Will It Survive the Decade?," *Educational Technology Research and Development*, vol. 44, no. 3, pp. 55–63, 1996.

[12] A. A. Piña, "Instructional design standards for distance learning," *Bloomington: Association for Educational Communications and Technology*, 2017.

[13] A. A. Piña, "AECT Instructional Design Standards for Distance Learning," *TechTrends*, vol. 62, no. 3, pp. 305–307, May 2018, doi: 10.1007/s11528-018-0282-9.

[14] J. Radianti, T. A. Majchrzak, J. Fromm, and I. Wohlgenannt, "A systematic review of immersive virtual reality applications for higher education: Design elements, lessons learned, and research agenda," *Computers & Education*, vol. 147, p. 103778, Apr. 2020, doi: 10.1016/j.compedu.2019.103778.

[15] Á. Antón-Sancho, D. Vergara-Rodríguez, D. G. Calatayud, and P. Fernández-Arias, "Virtual Reality as a Teaching Resource in Higher Education: Professors' Assessment," in *Pervasive Computing and Social Networking*, G. Ranganathan, R. Bestak, and X. Fernando, Eds., in Lecture Notes in Networks and Systems. Singapore: Springer Nature, 2023, pp. 139–149. doi: 10.1007/978-981-19-2840-6_11.

[16] A. F. Di Natale, C. Repetto, G. Riva, and D. Villani, "Immersive virtual reality in K-12 and higher education: A 10-year systematic review of empirical research," *British Journal of Educational Technology*, vol. 51, no. 6, pp. 2006–2033, 2020.

[17] M. J. Maas and J. M. Hughes, "Virtual, augmented and mixed reality in K–12 education: a review of the literature," *Technology, Pedagogy and Education*, vol. 29, no. 2, pp. 231–249, Mar. 2020, doi: 10.1080/1475939X.2020.1737210.

[18] D. Vergara, Á. Antón-Sancho, J. Extremera, and P. Fernández-Arias, "Assessment of Virtual Reality as a Didactic Resource in Higher Education," *Sustainability*, vol. 13, no. 22, Art. no. 22, Jan. 2021, doi: 10.3390/su132212730.

[19] A. Nichols Hess and K. Greer, "Designing for Engagement: Using the ADDIE Model to Integrate High-Impact Practices into an Online Information Literacy Course," *Communications in Information Literacy*, vol. 10, no. 2, Dec. 2016, doi: 10.15760/comminfolit.2016.10.2.27.

[20] R. M. Branch, *Instructional Design: The ADDIE Approach*. Boston, MA: Springer US, 2009. doi: 10.1007/978-0-387-09506-6.

[21] K. L. Gustafson and R. M. Branch, "What is instructional design? Trends and Issues in Instructional Design and Technology," *Saddle River, NJ: Merrill/Prentice Hall*, 2002.

[22] I. Visscher-Voerman and K. L. Gustafson, "Paradigms in the theory and practice of education and training design," *ETR&D*, vol. 52, no. 2, pp. 69–89, Jun. 2004, doi: 10.1007/BF02504840.

[23] A. Arslan, "Instructional Design Considerations for Flipped Classroom," *International Journal of Progressive Education*, vol. 16, no. 6, pp. 33–59, Dec. 2020, doi: 10.29329/ijpe.2020.280.3.

[24] M. Fragkaki, I. Hatzligeroydis, Z. Palkova, and K. Kovas, "Instructional Design in Virtual Reality Environments: The case of Palestinian HEIs," in *10th International Conference on Information, Intelligence, Systems and Applications, IISA 2019*, Institute of Electrical and Electronics Engineers Inc., 2019. doi: 10.1109/IISA.2019.8900765.

[25] B. Kitchenham, "Procedures for performing systematic reviews," *Keele, UK, Keele University*, vol. 33, no. 2004, pp. 1–26, 2004.

[26] M. Shippee and J. Lubinsky, "Training and Learning in Virtual Reality: Designing for Consistent, Replicable, and Scalable Solutions," in *International Conference on Electrical, Computer, and Energy Technologies, ICECET 2021*, Institute of Electrical and Electronics Engineers Inc., 2021. doi: 10.1109/ICECET52533.2021.9698487.

[27] M. Mulders, J. Buchner, and M. Kerres, "Virtual Reality in Vocational Training: A Study Demonstrating the Potential of a VR-based Vehicle Painting Simulator for Skills Acquisition in Apprenticeship Training," *Technology, Knowledge and Learning*, 2022, doi: 10.1007/s10758-022-09630-w.

[28] F. Castronovo *et al.*, "Design and development of a virtual reality educational game for architectural and construction reviews," in *ASEE Annual Conference and Exposition, Conference Proceedings*, American Society for Engineering Education, 2019. [Online]. Available: https://www.scopus.com/inward/record.uri?eid=2-s2.0-85078720216&partnerID=40&md5=54dcf061fbbd27dd550dcc7773c6b73b