Revista Thema

v.24 | n.2 | 2025

p.1-13

DOI: https://doi.org/10.15536/revistathema.24.2025.3610

ISSN: 2177-2894 (online)

CIÊNCIAS HUMANAS

Competences and Online Laboratories: A Systematic Literature Review

***Competências e Laboratórios On-line**: Uma Revisão Sistemática da Literatura*

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ABSTRACT

This work presents a systematic literature review aimed at listing the competences associated with the use of online laboratories. The PRISMA model was employed to conduct the review, considering papers published in journals and conference proceedings between 2013 and 2023, and indexed in the ACM Digital Library, IEEExplore, Scopus, and Web of Science databases. Studies addressing competences in online laboratories were included, while other document types, studies unrelated to the topic, or with irrelevant results to the

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v.24 | n.2 | 2025
p.1-13
DOI: https://doi.org/10.15536/revistathema.24.2025.3610
ISSN: 2177-2894 (online)

research questions were excluded. The search in the databases was carried out in October 2023, yielding 953 documents, with 309 duplicates removed, and 609 documents removed during the screening process, adhering to the inclusion and exclusion criteria. From the 7 selected papers, 7 competences were identified across 3 distinct areas, linking their knowledge, skills, and attitudes. This study presents a set of competences related to remote laboratories, which can be used to further improve the development of these educational resources, as well as the pedagogical aspects of their application. However, further research in this area is needed to provide a more detailed description of the related competences.

Keywords: Systematic literature review, competences, knowledge, skills, attitudes, remote laboratories.

RESUMO

Este trabalho apresenta uma revisão sistemática da literatura com o objetivo de relacionar as competências ligadas à utilização de laboratórios on-line. Foi utilizado o modelo PRISMA para conduzir a revisão, considerando artigos publicados em revistas e anais de eventos entre 2013 e 2023, e indexados nas bases ACM Digital Library, IEEExplore, Scopus e Web of Science. Foram incluídos trabalhos que tratam de competências em laboratórios on-line, e excluídos outros tipos de documentos, documentos que não tratam do tema ou têm resultados irrelevantes para as perguntas de pesquisa. A pesquisa nas bases de dados foi realizada em outubro de 2023, e foram encontrados 953 documentos, excluindo-se 309 duplicados, e 609 na triagem, de acordo com os critérios de inclusão e exclusão. Dos 7 trabalhos selecionados, foram extraídas 7 competências em 3 diferentes áreas, e relacionados seus conhecimentos, habilidades e atitudes. Este estudo apresenta um conjunto de competências relacionadas a laboratórios remotos, que podem ser utilizadas para aprimorar o desenvolvimento desses recursos educacionais, bem como os aspectos pedagógicos de sua aplicação. No entanto, mais pesquisas nessa área são necessárias para fornecer uma descrição mais detalhada das competências relacionadas.

Palavras-chave: *Revisão sistemática da literatura, competências, conhecimentos, habilidades, atitudes, laboratórios remotos.*

1. INTRODUCTION

The technological advancements have revolutionized education, making it more flexible and accessible, providing multimedia resources, and enhancing learning through interactive tools, including online resources, thus expanding teaching and learning possibilities. This popularization of digital technologies is also reflected in Brazilian public schools. According to the TIC Educação survey (Comitê Gestor da Internet no Brasil, 2022), 82.5% of these schools have internet access in the classroom. However, when it comes to science laboratories, according to Ministério da Educação (2019), only 38.8% of schools have access to this resource.

In this context, the popularization of digital technologies has enabled laboratory activities to explore new horizons. Online laboratories are educational labs in which students and equipment are not in the same physical space. Unlike traditional hands-on laboratories, where students manually operate the equipment, online laboratories can be remote, where the user controls real equipment over the Internet, virtual, which are based on mathematical models and fully digital, and hybrid, which combine characteristics of both (May, 2023). The figure bellow (Figure 1) explores the classification of educational laboratories:

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DOI: https://doi.org/10.15536/revistathema.24.2025.3610
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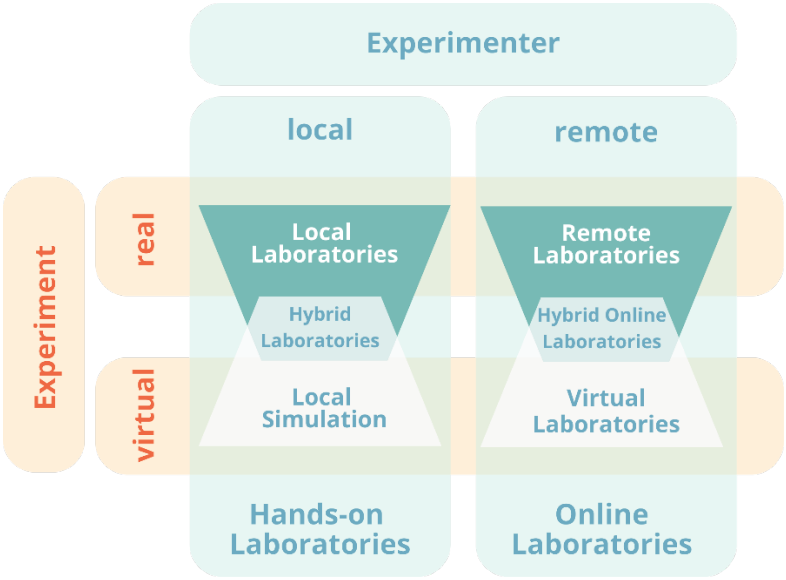
Figure 1 – Classification of Laboratories



Source: Adapted from Zutin et al. (2010).

These laboratories allow users to conduct a variety of experiments, emulating the experience of a practical laboratory while introducing unique features not found in traditional hands-on environments. Online experimentation is mediated by software applications with graphical interfaces rather than direct interactions with laboratory equipment. As a result, the user experience becomes a combination of various integrated technologies that recreate the sensation of handling real equipment, with different levels of abstraction (Beraldo, 2021). In this sense, one of the main advantages of this technology is its convenience in scheduling, access, and use: students can utilize the laboratories anytime and from anywhere, enabling more personalized learning experiences. It can also reduce costs associated with traditional practices, such as equipment maintenance and storage (Silva et al., 2020).

That said, online laboratories require distinct skills from those needed in traditional lab settings, including proficiency in software, problem-solving abilities related to connectivity, and aptitude for online communication and collaboration. Thus, a comprehensive understanding of competences related to remote laboratories is crucial to ensure that students and educators are adequately prepared to face the challenges of this educational environment.

Perrenoud (1999) defines competences as "the ability to effectively act in a specific type of situation, supported by knowledge, but not limited to it". In this regard, the European Commission (2019) considers competences as a "set of knowledge, skills, and attitudes" and Silva, Machado and Behar (2022) state that these "with the safe and critical use of a Digital Technology, allow the subject to solve certain basic problems in all areas in life". Knowledge encompasses established concepts, facts, numbers, ideas, and theories that underpin the understanding of specific fields or subjects. On the other hand, skills refer to the ability to perform processes effectively, leveraging existing knowledge to achieve desired outcomes. Attitudes encompass one's mindset and disposition, influencing their responses and actions towards ideas, individuals, or various situations.

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It is noteworthy that remote laboratories are employed across a wide range of disciplines and educational contexts, spanning from sciences and engineering to healthcare, at various educational levels. Furthermore, the technology associated with remote laboratories is continually evolving, with the emergence of new tools and platforms.

Thus, the aim of this study is to list the competences, and consequently the knowledge, skills, and attitudes, related to the use of online laboratories. In addition to this Introduction section, the paper presents the Related Work in Section 2, the Methodological Procedures in Section 3, the Results Analysis and Discussion in Section 4, and the Study Conclusions in Section 5.

2. RELATED WORK

Post et al. (2019) present a framework of digital competences for student laboratories based on a review of empirical studies. The framework delineates a set of competences, with five generic competences being addressed in most student laboratories: collaboration, communication, problem-solving, critical thinking, and creativity.

Terkowsky, Frye, and May (2019) discuss the potential of online laboratories in developing competences relevant to the "Working World 4.0". The authors identify a range of competences that are crucial for engineers in the digital era and examine how online laboratories can be utilized to foster these competences. The analysis results demonstrate that online laboratories can serve as a valuable tool for competence development within the context of Industry 4.0.

Menacho et al. (2016) present a study on the use of online laboratories to enhance competence development in students. The authors propose a Competence-Based Learning Management System (CBLMS) that integrates remote laboratories with learning activities and assessment tools. The study findings indicate that the utilization of remote laboratories can assist students in developing required competences more effectively.

Vega and Fonseca (2019) discuss assessing competences through online laboratory platforms. The most commonly used assessment methods include questionnaires, laboratory tests, and rubrics. The authors categorize types of competences as conceptual, involving the ability to understand and apply knowledge to solve problems, and procedural, involving the ability to apply knowledge and skills in a creative and critical manner. Challenges for improving competence assessment in this context include the need to develop specific assessment instruments and provide training for teachers in the use of assessment tools.

3. MATERIALS AND METHODS

This research is of an applied nature, which, according to Farias Filho and Arruda Filho (2013, p. 62), "has its results geared towards practical application," utilizing a qualitative approach that aims to "deepen the complexity of specific phenomena, facts, and processes," and to "address particular questions with a level of reality that cannot be quantified" (MINAYO; SANCHES, 1993).

Regarding its objectives, this research can be classified as descriptive, which, according to Farias Filho and Arruda Filho (2013, p. 63), "seeks to describe the characteristics of a specific population or phenomenon." The technical procedures conducted in this study allow it to be classified as

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bibliographic research, which, according to Gil (2002, p.44), is "developed based on previously elaborated material, mainly consisting of books and scientific articles."

The reviewing technique employed, systematic literature review, is defined by Kitchenham and Charters (2007) as "a means of identifying, evaluating, and interpreting all available relevant research on a specific research question, or thematic area, or phenomenon of interest." Therefore, this review aims to map primary studies on competences for online laboratories.

To do so, this study employs the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) model, in its 2020 version, designed to assist reviewers in transparently reporting why the review was conducted, what the authors did, and what they found. The model consists of a flow diagram and two checklists that guide authors in the review and meta-analysis process (PAGE et al., 2021).

3.1. PROTOCOL

The research questions defined based on the outlined objective are presented below in Table 1:

Table 1 – Research Questions

	Research Questions
Q1	What are the types of competences, their contexts, and subjects?
Q2	What is the knowledge, skills, and attitudes related to online laboratories?

Source: Compiled by the authors (2023).

The research was conducted in the scientific databases ACM Digital Library, IEEExplore, Scopus, and Web of Science, using the keywords shown in Table 2.

Table 2 – Keywords

Categoy	**Keyword**
Competences	*competence*
	skill
	knowledge
	attitude
	profile
	metric
Online Laboratories	*remote laborator**
	remote experimentation
	*online laborator**

Source: Compiled by the authors (2023).

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The queries group keywords within the same category using the boolean operator OR, and between categories using the operator AND, considering Title, Abstract, and Keywords when available, and documents published between 2013 and 2023. The queries for each database are presented in Table 3.

Table 3 – Databases and queries

Databases	**Queries**
ACM Digital Library	*[[All: "competence"] OR [All: "skill"] OR [All: "knowledge"] OR [All: "attitude"] OR [All: "profile"] OR [All: "metric"]] AND [[All: "remote laborator*"] OR [All: "remote experimentation"] OR [All: "online laborator*"]]*
IEEExplore	*(("competence" OR "skill" OR "knowledge" OR "attitude" OR "profile" OR "metric") AND ("remote laborator*" OR "remote experimentation" OR "online laborator*"))*
Scopus	*TITLE-ABS-KEY (("competence" OR "skill" OR "knowledge" OR "attitude" OR "profile" OR "metric") AND ("remote laborator*" OR "remote experimentation" OR "online laborator*"))*
Web of Science	*(("competence" OR "skill" OR "knowledge" OR "attitude" OR "profile" OR "metric") AND ("remote laborator*" OR "remote experimentation" OR "online laborator*"))*

Source: Compiled by the authors (2023).

The inclusion and exclusion criteria for this research are presented in the following Table 4:

Table 4 – Inclusion and exclusion criteria

Inclusion criteria	**Exclusion criteria**
IC1 - Studies addressing competences and online laboratories.	EC1 - Theses and dissertations, reports, standards, manuals, books, and book chapters EC2 - Studies that do not address the research topic EC3 - Studies irrelevant to the research questions

Source: Compiled by the authors (2023).

4. RESULTS AND DISCUSSION

The search in the databases was conducted on October 12, 2023, initially returning 953 documents: 43 from ACM Digital Library, 149 from IEEExplore, 490 from Scopus, and 271 from Web of Science. Subsequently, 309 duplicate papers were removed, and after reading the titles and abstracts, 596 papers that did not address the research topic were excluded. Additionally, 2 documents with unavailable full text were disregarded, leaving 18 documents for full-text reading. After reviewing the full text, 7 studies were selected, listed in the appendix and described below. The result of each step of the protocol is detailed in Figure 2.

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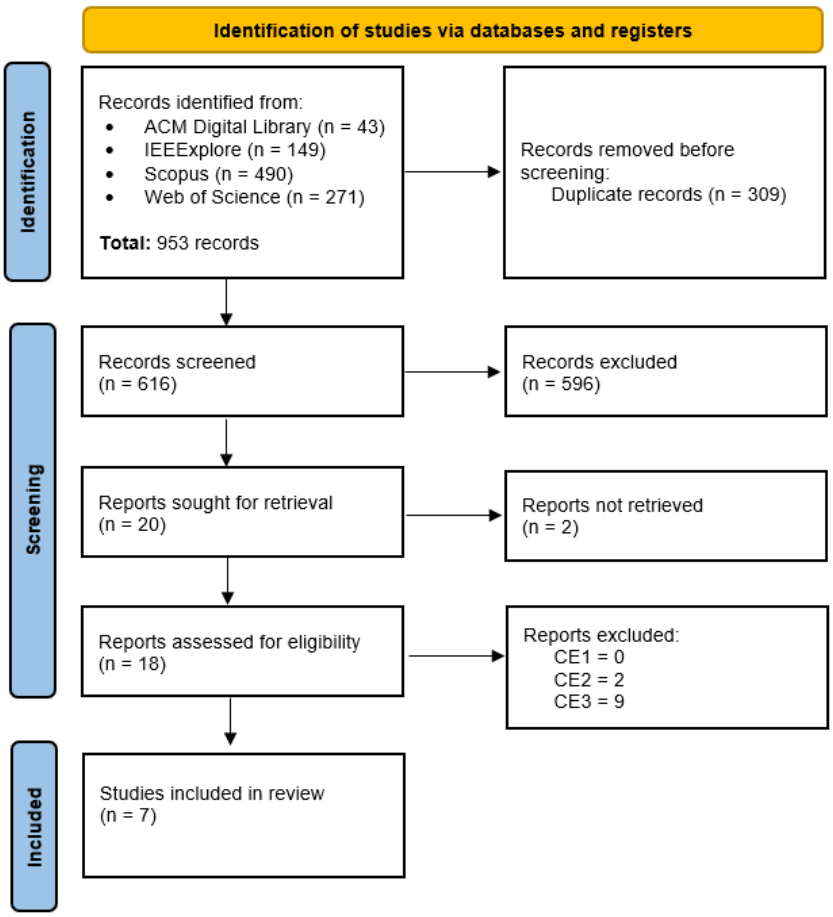
Figure 2 – Stages conducted in the review



Source: Compiled by the authors, based on Page et. Al (2021).

4.1. STUDIES INCLUDED

Study [1] presents a remote laboratory based on a 3D virtual environment that allows students to conduct real electronics experiments over the Internet. The eLab3D laboratory was designed to provide students with a more flexible, motivating, and personalized learning experience, enabling them to acquire most of the practical competences that would be achieved in an on-site electronics laboratory.

On the other hand, work [2] involves the development of a remote laboratory to strengthen the competences of students in computer systems engineering in a robotics course. The study identifies the competences related to the course that are essential for the remote laboratory.

Document [3] follows a similar path by considering the development of an augmented reality-based remote laboratory embedded in a game, focusing on the competences related to a programming discipline, just as document [4] presents a remote laboratory developed for micropipetting skills development.

The study conducted in work [5] presents a matrix of digital competences for laboratories, developed based on a literature review and a study with engineering students. The article also provides a set

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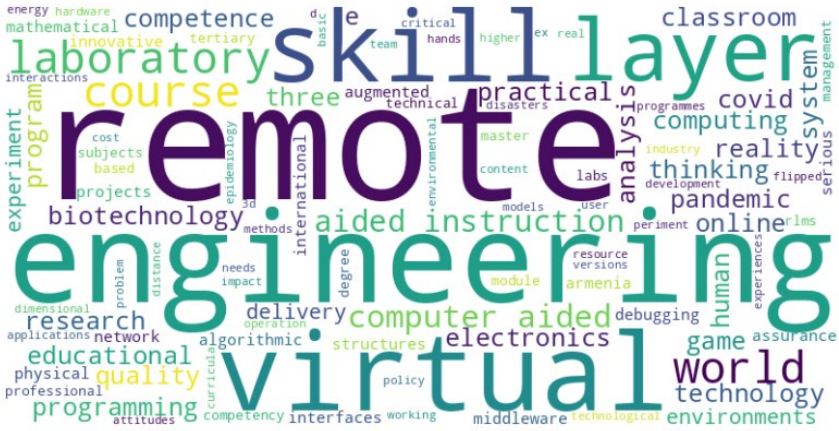
of recommendations for the development of remote laboratories that meet the needs of IoT-generation students.

Work [6] describes a competence-based approach for remote laboratories. The authors introduce a remote laboratory for electrical engineering supported by HomeLabKit, a small box of electronic components, and designed under the framework of Competence-Based Learning.

Lastly, the study conducted in [7] describes a set of remote organic chemistry experiments, evaluating them based on socio-affective competences, and comparing them with hands-on experiences. Figure 3 shows a word cloud from the keywords of the accepted documents.

Figure 3 – Accepted documents word cloud



Source: Compiled by the authors.

4.2. QUESTION 1: WHAT ARE THE TYPES OF COMPETENCES, THEIR CONTEXTS, AND SUBJECTS?

Document [2] categorizes competences as "general," related to social responsibility and citizenship, and "specific," related to problem-solving. The authors of [6] introduce the concept of "personal competences," while using "professional competence" as synonymous with general competence, adding communication skills to this description. The term "specific competences" is also used to describe the competences necessary for a specific problem that the student will encounter, as mentioned in works [1], [3], and [4]. Work [5] refers to the term "technical competence" to broadly describe the gain after a laboratory activity. On the other hand, the authors of work [7] present "learning competences" as the representation of students' capabilities considering the skill level. Meanwhile, document [8] addresses aspects related to "emotional competence" to identify students' expectations and emotional experience.

Regarding contexts and subjects, all studies focused on competences of higher education students, mostly in the fields of engineering and technology.

4.3. QUESTION 2: WHAT IS THE KNOWLEDGE, SKILLS, AND ATTITUDES RELATED TO ONLINE LABORATORIES?

Documents [1], [4], and [6] address specific competences, presenting the skill "laboratory practice and experimentation," with [1] in the context of a remote circuit laboratory, while [4] and [6] are

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situated in the context of remote automation laboratories. Document [6] also presents a series of skills and attitudes based on the criteria for the accreditation of engineering courses by ABET (Accreditation Board for Engineering and Technology).

Document [2] includes "Social Responsibility and Citizenship" as a general competence, along with a set of specific skills necessary for conducting activities in the remote laboratory.

4.4. COMPETENCE BOARD

In this work, grouping the concepts presented, the final group of competences can be classified as general, technical, and learning competences. In this context, the National Common Curricular Base defines general competences as the mobilization of knowledge, skills, and attitudes to "address complex demands of daily life, full exercise of citizenship, and the world of work" (MINISTRY OF EDUCATION, 2018). Technical competences, on the other hand, are understood by Szasz (2015) as "safely performing a procedure or task independently." Lastly, learning competences, according to Le Deist and Winterton (2005), are related to "learning how to learn."

Based on the data extracted from the documents, Table 5 presents the competences related to online laboratories:

Table 5 – Competences related to online laboratories

Areas	Documents	Competences	Knowledge	Skills	Attitudes
General competences	[2]	Social responsibility and citizenship			Impact generation on society
	[6]	Social competence	Interdisciplinary thinking	Communication and cooperation	Teamwork
			Autonomy	Ethic	Learn from errors
	[8]	Emotional competence	Self-knowledge		
Technical competences	[2] [3] [6]	Cognitive competence	Mathematics, science and engineering	Solution design	Planning
			Logical, intuitive and creative thinking	Problem solution	Identify, formulate and solve problems
	[1] [2] [4] [6]	Practical competence	Instrumentation	Laboratory practice and experimentation	Use modern techniques and tools
			Data	Data analysis	Perform statistical analysis
			Security	Model definition	
			Sensory conscience	Psychomotor	
Learning competences	[7]	Entry competence	Specific knowledge for the proposed exercise	Necessary skills to solve an exercise	Apply knowledge correctly
		Hidden competence	Lack of knowledge in a area that makes the student make mistakes		

Source: Compiled by the authors (2023).

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5. FINAL CONSIDERATIONS

This review discusses the different areas of competence and their knowledge, skills, and attitudes in the context of online laboratories, analyzing different approaches and providing a competence framework based on the state of the art.

The importance of online laboratories in the current landscape is highlighted, where learning mediated by digital technologies is becoming increasingly prevalent. These tools offer an effective solution to overcome geographical barriers and provide students with practical experiences regardless of their location.

The diversity in the terms used to describe competences reflects the complexity and variety of knowledge, skills, and attitudes present in different contexts, even within a specific domain. Despite the limited number of resulting works, this review encompasses a considerable number of approaches. This set of competences can be used to further improve the technological development of online laboratories, as well as the pedagogical aspects of their application.

Finally, although this review has provided valuable insights, it is acknowledged that there is much more to be explored in this field. Considering the 8 key competences for lifelong learning outlined by the European Union (EUROPEAN COMISSION, 2019), few were addressed in the analyzed works. Not even digital competences, essential for the use of digital technologies, were analyzed in relation to online laboratories. Further research is needed to continue investigating this topic, providing a more detailed description of the different competences required in the field.

6. REFERENCES

BRASIL. **Lei de Diretrizes e Bases da Educação**. 20 dez. 1996. Available at: https://www.planalto.gov.br/ccivil_03/leis/l9394.htm. Access on: 12 Oct. 2023.

BERALDO, A. L.; OLIVEIRA, T.; STRINGHINI, D. Laboratórios remotos e virtuais no Brasil com foco no ensino: Uma revisão sistemática da literatura. **Revista Novas Tecnologias na Educação**, v. 19, n. 1, p. 330–340, jul. 2021. DOI: 10.22456/1679-1916.118493.

COMITÊ GESTOR DA INTERNET NO BRASIL. **TIC Educação: Pesquisa sobre o Uso das Tecnologias de Informação e Comunicação nas Escolas Brasileiras**. [*S. l.*]: Comitê Gestor da Internet no Brasil, 2022. Available at: https://www.cetic.br/media/docs/publicacoes/2/20221121124124/tic_educacao_2021_livro_eletronico.pdf. Access on: 1 Jan. 2023.

DIAS, I. S. Competências em educação: conceito e significado pedagógico. **Psicologia Escolar e Educacional**, [*s. l.*], v. 14, n. 1, p. 73–78, 2010.

EUROPEAN COMISSION. **Key competences for lifelong learning**. [*S. l.*]: Publications Office of the European Union, 2019. Available at: https://data.europa.eu/doi/10.2766/569540. Access on: 1 Jan. 2023.

FARIAS FILHO, M. C.; ARRUDA FILHO, E. J. M. **Planejamento da pesquisa científica**. 1. ed. São Paulo: Atlas, 2013. ISBN 9788522476268.

GIL, A. C. **Como Elaborar Projetos de Pesquisa**. [S.l.]: Atlas, 2002.

DOI: https://doi.org/10.15536/revistathema.24.2025.3610
ISSN: 2177-2894 (online)

KITCHENHAM, B.; CHARTERS, S. **Guidelines for performing Systematic Literature Reviews in Software Engineering**. [*S. l.*]: Keele University e Durham University, 2007. Available at: https://www.bibsonomy.org/bibtex/aed0229656ada843d3e3f24e5e5c9eb9. Access on: 1 jan. 2023.

LE DEIST, F. D.; WINTERTON, J. What Is Competence?. **Human Resource Development International**, [s. l.], v. 8, n. 1, p. 27–46, 2005.

MAY, D.; ALVES, G. R.; KIST, A. A.; ZVACEK, S. M. Online Laboratories in Engineering Education Research and Practice. In: **INTERNATIONAL Handbook of Engineering Education Research**. [S.l.]: Routledge, 2023. Num Pages: 28. ISBN 978-1-00-328748-3.

MENACHO, A. et al. Competence-based learning management systems: Practices using remote laboratories to improve the use of the subjects and get required competences. Em: **2016 13th International Conference on Remote Engineering and Virtual Instrumentation (REV)**. [S. l.: s. n.], 2016. p. 109–111.

MINAYO, M. C. d. S.; SANCHES, O. Quantitative and qualitative Methods: opposition or complementarity? **Cadernos de Saúde Pública**, Scielo, v. 9, p. 237 – 248, 09 1993. ISSN 0102311X.

MINISTÉRIO DA EDUCAÇÃO. **Base Nacional Comum Curricular: Educação é Base**. 2018. Available at: http://basenacionalcomum.mec.gov.br/images/BNCC_EI_EF_110518_versaofinal_site.pdf. Access on: 12 Oct. 2023.

MINISTÉRIO DA EDUCAÇÃO. **Números revelam deficiências das escolas de ensino médio**. [*S. l.*], 2019. Available at: http://portal.mec.gov.br/ultimas-noticias/33541-censo-escolar/73311-numeros-revelam-deficiencias-das-escolas-de-ensino-medio. Access on: 1 Jan. 2023.

NICOLETE, P. C. *et al.* Analysis of student motivation in the use of a Physics Augmented Remote Lab during the Covid-19 pandemic. *Em*: PROCEEDINGS OF THE IEEE GLOBAL ENGINEERING EDUCATION CONFERENCE (EDUCON 2021): WOMEN IN ENGINEERING, 2021. **Anais [...]**. [*S. l.*]: IEEE, 2021. p. 1040–1047. Available at: https://doi.org/10.1109/EDUCON46332.2021.9454104. Access on: 1 Jan. 2023.

ORDUÑA, P. *et al.* WebLabLib: New Approach for Creating Remote Laboratories. *Em*: CYBER-PHYSICAL SYSTEMS AND DIGITAL TWINS: PROCEEDINGS OF THE 16TH INTERNATIONAL CONFERENCE ON REMOTE ENGINEERING AND VIRTUAL INSTRUMENTATION, 2019. **Anais [...]**. [*S. l.*]: Springer, 2019. p. 477–488. Available at: https://link.springer.com/chapter/10.1007/978-3-030-23162-0_43#citeas. Access on: 1 Jan. 2023.

PAGE, M. J. *et al.* The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. **BMJ**, [*s. l.*], v. 372, p. n71, 2021.

PERRENOUD, P. **Construir as Competências Desde a Escola**. 1. ed. Porto Alegre: Artmed, 1999.

POST, L. *et al.* WP4: Review e-Competences. **IOT Rapid-Proto Labs.** 2019. Available at <https://www.rapidprotolabs.eu/wp-content/uploads/2020/06/D4.3_E-Competences_PUBLIC_12062020.pdf>. Access on: 21 Oct. 2023.

DOI: https://doi.org/10.15536/revistathema.24.2025.3610
ISSN: 2177-2894 (online)

SILVA, J. B. da *et al.* Laboratórios Remotos como Alternativa para Atividades Práticas em Cursos na Modalidade EAD. **EaD en Foco**, [*s. l.*], v. 10, n. 2, 2020. Available at: https://eademfoco.cecierj.edu.br/index.php/Revista/article/view/942. Access on: 1 Jan. 2023.

SILVA, K. K. A.; MACHADO, L. R.; BEHAR, P. A. Competências Digitais na Educação. *Em*: SILVA, KETIA KELLEN ARAÚJO; BEHAR, P. A. (ed.). **Competências Digitais em Educação: do conceito à prática**. 1ed. [*S. l.*]: Artesanato Educacional, 2022. p. 11–34.

SLIPUKHINA, I. Role of computer oriented laboratory training course in Physics for development of key competences of future engineers. **Advances in aerospace technology**, [*s. l.*], v. 58, n. 1, p. 96–101, 2014.

SZASZ, P. et al. Assessing Technical Competence in Surgical Trainees: A Systematic Review. **Annals of Surgery**, [s. l.], v. 261, n. 6, p. 1046, 2015.

TERKOWSKY, C.; FRYE, S.; MAY, D. Is a Remote Laboratory a Means to Develop Competences for the 'Working World 4.0'? A Brief Tentative Reality Check of Learning Objectives. *Em*: , 2019. **2019 5th Experiment International Conference (exp.at'19)**. [*S. l.: s. n.*], 2019. p. 118–122.

VUORIKARI, R.; KLUZER, S.; PUNIE, Y. **DigComp 2.2, The Digital Competence framework for citizens: with new examples of knowledge, skills and attitudes**. [*S. l.*]: Publications Office of the European Union, 2022. (Publications Office of the European Union). *E-book*. Available at: https://op.europa.eu/en/publication-detail/-/publication/50c53c01-abeb-11ec-83e1-01aa75ed71a1/language-en. Access on: 1 Jan. 2023.

VEGA, L. E. A.; FONSECA, B. B. Estudio sobre evaluación de competencias en la Plataforma de Laboratorios Remotos. **Serie Científica de la Universidad de las Ciencias Informáticas**, [*s. l.*], v. 12, n. 2, p. 54–66, 2019.

ZUTIN, Danilo Garbi; AUER, Michael E.; MAIER, Christian; NIEDERSTÄTTER, Michael. Lab2go — A repository to locate educational online laboratories. In: **IEEE EDUCON 2010 Conference**, 2010. p. 1741-1746. DOI: 10.1109/EDUCON.2010.5492412.

7. APPENDIX: SELECTED DOCUMENTS

[1] CARPENO, A.; LOPEZ, S.; ARRIAGA, J. Using remote laboratory eLab3D for a broader practical skills training in electronics. Em: **Proceedings of 2014 11th International Conference on Remote Engineering and Virtual Instrumentation**, REV 2014. [S. l.: s. n.], 2014. p. 98–99.

[2] TIRADO-MENDOZA, G.; REYES-RODRIGUEZ, E.; BAUTISTA-ZÚÑIGA, L. Laboratory in the context of the Sars-CoV-2 Pandemic to Strengthen the Competences of Students of the Computer Systems Engineering Program. Em: **Proceedings of the LACCEI international Multi-conference for Engineering, Education and Technology**. [S. l.: s. n.], 2021.

[3] GUENAGA, M. et al. Serious games, remote laboratories and augmented reality to develop and assess programming skills. Em: **Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics).** [S. l.: s. n.], 2014. p. 29–36.

DOI: https://doi.org/10.15536/revistathema.24.2025.3610
ISSN: 2177-2894 (online)

[4] HAASE, J. Teaching Engineering Students Practical Skills By Means of Remote Laboratories. Em: **IEEE Region 10 Humanitarian Technology Conference, R10-HTC**. [S. l.: s. n.], 2022. p. 419–424.

[5] JAWAD, M. N. et al. Remote laboratory exercise to develop micropipetting skills. **Journal of Microbiology and Biology Education**, [s. l.], v. 22, 2021.

[6] KAMMERLOHR, V.; PFEIFFER, A.; UCKELMANN, D. Digital Laboratories for Educating the IoT-Generation Heatmap for Digital Lab Competences. Em: , 2021. **Anais [...].** [S. l.: s. n.], 2021. p. 3–20.

[7] UMBLEJA, K.; KUKK, V.; JAANUS, M. Competence-Based Approach to Learning. Em: , 2013. **Anais [...].** [S. l.: s. n.], 2013. p. 552–559.

[8] YONAI, E.; BLONDER, R. Uncovering the Emotional Aspect of Inquiry Practices in a Remote SEM Environment and the Development of a Designated Questionnaire. **Journal of Chemical Education**, [s. l.], v. 99, p. 3932–3945, 2022.

[Updated in: **23 Jul. 2025**]

Submission: 31/10/2023

Accepted: 07/10/2025