

**ОБЩАЯ ПЕДАГОГИКА, ИСТОРИЯ ПЕДАГОГИКИ И ОБРАЗОВАНИЯ/GENERAL PEDAGOGY, HISTORY OF PEDAGOGY AND EDUCATION**DOI: <https://doi.org/10.60797/IRJ.2026.169.114> EDN: FFAMYE**ADAPTING INDUSTRIAL AUGMENTED REALITY FOR CAREER GUIDANCE THROUGH CONTEXTUAL AND LOW-COST LEARNING SCENARIOS**

Research article

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Abstract

Augmented reality (AR) in manufacturing has long passed the experimental stage and entered everyday operational practice. The assembly of aircraft wiring harnesses, the routine servicing of complex equipment, and the onboarding of new personnel in days rather than months are no longer headline-worthy demonstrations but quietly accepted parts of the production cycle. The natural question is whether this accumulated experience can travel beyond the shop floor and reach the moment when a teenager first attempts to decide what to become. The present paper builds on the concept of “minimal AR authoring” and adapts it to the very different goals of vocational guidance. The underlying logic is straightforward: expensive three-dimensional models are replaced with synchronously played reference video, which causes the cost of content production to drop sharply while preserving the perceptual benefits of contextual overlay. A participant performs real work operations while graphical cues are projected into the natural field of view, so there is no need to memorise instructions in advance, and a substantial part of working memory is freed for the task itself. The data accumulated in industrial deployments and pilot educational projects suggest that hands-on, do-it-yourself exposure to a profession through AR helps young people gauge their actual fit for a given line of work far more reliably than lectures, glossy brochures, or guided tours. Critically, the entire pipeline runs on ordinary consumer smartphones, which is a decisive advantage for schools and colleges operating on tight budgets and unable to procure specialised industrial AR hardware.

Keywords: augmented reality, career choice, industrial workforce training, visual action guidance, minimal AR authoring, working memory, vocational self-determination, immersive educational technologies, contextual overlay, learning by doing.

АДАПТАЦИЯ ПРОМЫШЛЕННОЙ ДОПОЛНЕННОЙ РЕАЛЬНОСТИ ДЛЯ ПРОФЕССИОНАЛЬНОЙ ОРИЕНТАЦИИ С ПОМОЩЬЮ КОНТЕКСТУАЛЬНЫХ И НИЗКОЗАТРАТНЫХ СЦЕНАРИЕВ ОБУЧЕНИЯ

Научная статья

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Аннотация

Дополненная реальность (ДР) в производстве уже давно вышла за рамки экспериментальной стадии и стала частью повседневной производственной практики. Сборка электропроводки самолетов, плановое техническое обслуживание сложного оборудования и введение в должность новых сотрудников за считанные дни, а не месяцы — все это уже не является поводом для сенсаций, а тихо и естественно вошло в производственный цикл. Возникает логичный вопрос: может ли накопленный опыт выйти за пределы производственного цеха и повлиять на момент, когда подросток впервые пытается определиться с выбором профессии? Настоящая статья основана на концепции «минимального создания контента для ДР» и адаптирует её к совершенно иным целям профессиональной ориентации. Логика, лежащая в основе этого подхода, проста: дорогостоящие трехмерные модели заменяются синхронно воспроизводимым справочным видео, что приводит к резкому снижению затрат на производство контента при сохранении преимуществ наложения контекста на реальное изображение. Участник выполняет реальные рабочие операции, в то время как графические подсказки проецируются в естественное поле зрения, поэтому нет необходимости заранее запоминать инструкции, и значительная часть оперативной памяти освобождается для выполнения самой задачи. Данные, накопленные в ходе промышленного внедрения и пилотных образовательных проектов, свидетельствуют о том, что практическое, самостоятельное знакомство с профессией с помощью ДР помогает молодым людям гораздо надежнее оценить свою реальную пригодность к той или иной сфере деятельности, чем лекции, гляцевые брошюры или экскурсии с гидом. Важно отметить, что весь процесс работает на обычных бытовых смартфонах, что является решающим преимуществом для школ и вузов, которые работают в условиях ограниченного бюджета и не могут приобрести специализированное промышленное оборудование для дополненной реальности.



Ключевые слова: дополненная реальность, выбор профессии, подготовка производственных кадров, визуальное руководство действиями, минимальное создание контента для ДР, оперативная память, профессиональная самоопределенность, иммерсивные образовательные технологии, контекстная накладка, обучение через практику.

Introduction

The structure of the modern economy is changing at a pace that significantly outstrips the inertia of educational institutions. New occupations appear, traditional ones merge or disappear, and the technological content of the work performed under a familiar job title may shift radically within a few years. Against this background, the instruments by which schoolchildren form their first ideas about the world of work remain largely unchanged: a lecture given by a careers counsellor, a glossy brochure produced by a sponsoring enterprise, or a guided tour conducted at a respectful distance from the actual production line behind a safety railing. None of these formats leaves more than a surface impression. There is no opportunity to try anything with one's own hands, to feel the resistance of a tool, to experience the tempo of a real operation, or to encounter the small frictions that ultimately determine whether a profession suits a particular person. Without such hands-on action, any picture of a profession remains essentially bookish and is easily displaced by stereotypes drawn from films, social media, or family expectations.

The mismatch between the speed of industrial change and the conservatism of career-guidance practices generates measurable social costs. Students enter higher and vocational education with imagined images of a profession that bear little resemblance to the daily reality of the workplace, which contributes to high rates of dropout in the first two years of study and to subsequent lateral movement into unrelated fields. Employers, in turn, complain about the protracted adaptation of graduates and about the difficulty of forecasting the demand for specific competencies. Analyses of job-market postings for immersive-technology specialists likewise reveal a persistent gap between the skills advertised by employers and those formed by traditional schooling [1]. A career-guidance instrument that compresses the gap between perception and practice would therefore address a problem that is simultaneously pedagogical, economic, and personal.

A small but growing body of work has begun to explore how immersive technologies may contribute to this task. WebAR-based career-guidance quests deployed at the level of an entire school system have shown that even lightweight browser-driven experiences noticeably improve the engagement of adolescents with information about professions [2]. Comparable experiments at the primary school level indicate that AR-supported applications can convey a sense of occupational activity much earlier than conventional methods [3]. These precedents suggest that the ground for a systematic transfer of industrial AR into career guidance is already partly prepared.

What is new in this paper concerns three closely related elements. First, methods of visual action guidance that have already been thoroughly field-tested in manufacturing are for the first time systematically transferred to the domain of career guidance, with explicit attention to the change in pedagogical goals that this transfer requires. Second, the principle of minimal AR is shown to be viable not only as a technical curiosity but as the basis for large-scale events conducted on a deliberately modest budget. Third, a model of short AR scenarios designed specifically to trigger vocational self-determination is proposed, and its key parameters — duration, hardware, structure of the participant's interaction — are described in a form that allows immediate replication at the level of a single school or an entire regional programme.

The aim of the work is straightforward: to construct a working model for transferring proven shop-floor AR solutions into the practice of school and college career guidance, while preserving their economic accessibility. The first objective is to compile and systematise the available data on the effectiveness of AR at industrial sites, with particular attention to those metrics — reduction of training time, decrease in error rates, relief of cognitive load — that have potential analogues in the educational setting. The second objective is to substantiate the visual-guidance method grounded in the idea of minimal authoring, distinguishing it both from conventional video instructions and from full-fledged industrial AR with three-dimensional tracking. The third objective is to formulate the principles by which industrial AR scenarios should be adapted for career-guidance tasks, recognising that the criterion of success here is not the flawless execution of an operation but the participant's ability to form a substantiated subjective judgement about the profession.

AR on the Factory Floor: What Already Works and What It Teaches

2.1. Industrial experience

Augmented reality has long ceased to be a novelty in manufacturing and has become one of the standard instruments of industrial training and operational support [4]. The Boeing Wire Harness project is a frequently cited example precisely because of how unspectacular its day-to-day use has become. A technician puts on a pair of AR glasses, and a three-dimensional wiring diagram is rendered directly on top of the real harness, with each conductor highlighted at the moment it must be routed and connected. The paper drawing, with its constant flicking back and forth between the diagram and the workpiece, becomes redundant. There is nothing visually dramatic about the result; the value lies in the disappearance of an entire layer of mediating documentation that used to consume both time and attention.

Comparable patterns are documented in many other domains, from the assembly of complex mechanical units [5] and the maintenance of medical equipment to the servicing of energy infrastructure. In each case the pattern is similar: an instruction that previously existed as a separate artefact — a paper manual, a tablet screen, a colleague's verbal explanation — is collapsed into the visual field of the worker, where it remains available without requiring an interruption of the action. This shift, modest as it sounds, has measurable consequences for the structure of expertise itself, because parts of the task that were previously stored as procedural memory can now be safely externalised, while the worker's attention is concentrated on those aspects that genuinely require judgement. Controlled studies in vocational and technical education consistently report parallel gains in achievement and self-efficacy when AR replaces conventional instructional formats [6].

2.2. Effects

According to data published by Aidar Solutions and SkillMaker, the deployment of AR in industrial training reproduces a small set of consistent effects across very different projects. The most visible of these is the contraction of training time, which falls by up to seventy-five per cent for complex operations and, in the most striking case documented by Boeing SkillMaker, compresses what used to be a year of preparation into a single working week. Equally important, although less photogenic, is the reduction of errors: because the instruction is anchored to a specific physical component, it is much harder to confuse that component with a visually similar neighbour, and entire categories of substitution mistakes simply disappear. Finally, cognitive load decreases in a way that is felt rather than measured; a systematic review of controlled AR studies across a range of instructional settings confirms the effect and links it directly to improved task performance [7]. The eyes no longer dart between paper and part, the gaze remains within the work zone, and the thread of action is preserved through the natural rhythm of the operation rather than reconstructed after each interruption.

It is worth emphasising that these three effects reinforce one another rather than acting independently. Faster training is partly a consequence of the lower cognitive load, since less mental effort is wasted on integrating fragmented information sources. Lower error rates feed back into faster training, because remedial work and the demoralising experience of repeated failure are reduced. The combined effect is a qualitatively different relationship between the novice and the task: the worker is allowed to be a beginner without being penalised for it, and the curve of competence becomes noticeably less steep. Similar reinforcement loops have been documented for the acquisition of psychomotor skills such as welding, where VR and AR systems progressively displace costly hands-on rehearsals without compromising the eventual quality of the technique [8].

2.3. Limitations

The principal obstacle to a wider use of these technologies outside industry is cost. Full-blown AR systems with three-dimensional tracking are not only expensive in terms of the hardware itself but are also tightly coupled to highly specialised content. The cost of developing such content is high, the integration of the system into the existing curriculum is laborious and demands significant methodological work [9], and the resulting interface is frequently so dense with controls and overlays that a novice user becomes lost within it. A systematic survey of AR applications in vocational settings confirms that uneven content quality and methodological fragmentation remain the dominant barriers even as the underlying technology matures [10]. Schools and colleges, which lack both the engineering resources of a large manufacturer and the budgets of a corporate training department, cannot realistically afford this configuration. Any serious attempt to bring AR into mass career guidance must therefore begin not by miniaturising industrial systems but by rethinking what subset of their effects is actually needed for the new task and how that subset can be achieved by far simpler means.

"Minimal Authoring": Making AR Cheap and Understandable

3.1. The core idea

The principle of minimal authoring is simple to the point of appearing trivial. A person watches a reference video and immediately repeats with their own hands what is shown on the screen. Crucially, the video is not viewed in isolation on a separate device but is overlaid on the real working scene, so that the demonstration and the participant's own action coincide in space and almost coincide in time. Unlike expensive industrial systems with three-dimensional tracking, the approach relies on what is sometimes called minimal AR authoring: content is produced quickly, cheaply, and without specialised equipment, since recording a clear demonstration of a task is something a domain expert can do with the same smartphone that the participants will later use to view it. A comparable design philosophy has been articulated in frameworks for motivational AR applications in vocational education, which deliberately favour lightweight content production over elaborate spatial modelling [11]. The asymmetry between the cost of producing content and its educational value is what makes the format attractive at scale.

Several practical features follow from this design choice. There is no requirement to model the workpiece or the tools in three dimensions, which removes the most expensive line item from any conventional AR project. There is no need to develop precise spatial tracking, because the participant aligns themselves to the demonstration by physical placement rather than by software registration. There is no obligation to install proprietary software on a controlled device, because ordinary mobile applications with camera access are sufficient. Each of these omissions individually saves resources; taken together, they shift the economic profile of AR from a capital-intensive industrial investment to something closer to the production of a short instructional video, while retaining most of the perceptual advantages of contextual overlay.

The model for transferring AR to career guidance can be described as a sequence of five stages that follow each other without sharp boundaries. The participant first observes the professional process through an AR overlay, which provides an initial structured impression. They then repeat the operations with their own hands, working alongside the demonstration rather than after it. The third stage consolidates this initial hands-on experience by allowing repetition without prompts, so that the participant can sense how much of the task they have actually internalised. The fourth stage explicitly grants time for reflection on what they have just felt, including aspects — boredom, satisfaction, physical fatigue, curiosity — that lectures and brochures cannot convey. Only after this sequence has been completed does the participant arrive at the fifth stage, where they are in a position to make an informed decision about whether the profession deserves further exploration. The logic is deliberately incremental: first one watches, then one does, then one thinks, and only then does one decide.

Table 1 - Four formats compared

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Characteristic	Video instructions	VR training	Conventional AR	Contextual AR
Link to reality	Absent during work	Fully virtual environment	Tight link to reality	High integration

Characteristic	Video instructions	VR training	Conventional AR	Contextual AR
Cognitive load	High (memorisation)	Moderate	Low	Minimal
Development complexity	Low	High	Very high	Medium / Low
Deployment cost	Minimal	High	Very high	Low
Hardware accessibility	Any screen	VR headsets	Industrial AR glasses	Smartphones / budget glasses

3.2. Advantages

Contextual AR is, in essence, a compromise, but a particularly well-balanced one. In terms of cost, it sits much closer to ordinary video instructions than to a professional industrial system, while in terms of pedagogical effect, it approaches that of full-fledged AR within the limits relevant to career guidance. The participant's hands remain busy with the actual work, the reference is held in peripheral vision rather than competing for central attention, and there is no need for repeated focal switching between the instruction and the workpiece. The result is an experience that feels less like “watching a video about welding” and more like “welding while being quietly guided”, and it is precisely this difference in subjective register that does the pedagogical work.

An additional and often overlooked advantage of the minimal-authoring approach concerns the longevity of the content. Because scenarios are short, modular, and inexpensive to record, they can be revised whenever a procedure changes, a new specialisation appears, or a partner enterprise updates its equipment. A library of such scenarios behaves more like a living catalogue than a fixed curriculum, and its ability to keep pace with the surrounding economy is itself a pedagogical asset.

Not a Skill, but Self-Determination: What Makes Career-Guidance AR Different

4.1. The specifics of career guidance

On the factory floor the goal of an AR-supported task is unambiguous: the worker must execute an operation correctly and without errors, and the system is judged by how reliably it supports that hard skill. In career guidance, the task is fundamentally different. What matters is not the precise reproduction of a movement but the formation of what may be called a subjective-evaluative attitude towards the work, that is, the participant's own felt sense of whether the activity attracts or repels them, whether its rhythm matches their temperament, and whether the kind of attention it demands is one they can comfortably sustain. Precision becomes secondary, while the texture of experience becomes primary. Immersive-reality experiments aimed at informed career decision-making show that this shift in criterion has empirical substance: participants exposed to an embodied preview of an occupation report substantially more considered choices than those given conventional descriptive material [12]. Transfr Inc. has demonstrated the same pattern in practice: when a participant is allowed to see the process through a craftsman's eyes, they begin to notice the underlying logic of each movement and the chain of reasoning that connects one step to the next, rather than perceiving the work as an opaque sequence of gestures.

This shift in goal has methodological consequences that are easy to underestimate. An industrial AR scenario may legitimately be evaluated by the percentage of operations performed correctly on the first attempt; a career-guidance scenario must be evaluated by the quality of the participant's subsequent reflection. The instrument is the same, but the criterion of success is different, and the design of the scenario must follow the criterion rather than the instrument. Evidence from immersive VR training for career adaptability points in the same direction: the measurable outcomes are psychological readiness and self-concept, not task execution [13].

4.2. Adaptation principles

Three principles govern the adaptation of industrial scenarios to the career-guidance setting. The first concerns the simplification of essence: the participant should be helped to understand not so much the question of how exactly an operation is performed as the question of why it is performed in this particular way, since grasping the purpose of an operation contributes more to vocational self-understanding than reproducing it precisely. The second principle gives a clear preference to live video over animation, because a real production cycle captured on camera carries information about tempo, sound, posture, and material that no drawn diagram can convey, and these are exactly the cues by which a teenager intuitively decides whether a profession feels like their own. The third principle imposes a strict limit on duration: each scenario should last no more than five to ten minutes, because beyond that interval the attention of an adolescent participant predictably drifts, the experience loses its sharpness, and the fragile link between observation and reflection is broken.

4.3. Application scenarios

Three classes of scenarios prove particularly productive in school and college settings. The first invites the participant to look inside the process, for instance, to follow a CNC machine through a complete cycle from blank to finished part, with the AR overlay highlighting the moments at which the operator's decisions actually matter. The second class allows the participant to try a simple assembly operation themselves, performing the work under AR guidance and receiving immediate visual feedback before moving on to the next attempt. The third class is concerned with navigating the working environment as such: where the tools are located, where the safety zone runs, how parts flow through the workstation, and which auxiliary actions occupy more time than the operations they serve. Together these three formats reproduce, in compressed form, the principal modes in which a worker actually inhabits a workplace, and they do so without requiring the participant to commit in advance to any particular profession.

Implementation and What the Data Show

5.1. Technical solution

The platform on which the proposed model is deployed is intentionally mobile and unceremonious. A consumer smartphone, optionally complemented by an inexpensive pair of AR glasses, is sufficient for all the scenarios described above; the only firm technical requirement is cross-platform support, so that a single scenario can be launched on devices running either Android or iOS without modification. A student arriving at a career-guidance event uses their own phone under a bring-your-own-device arrangement, which removes the principal procurement obstacle that has historically prevented schools from experimenting with immersive technologies. Where the context requires reliable identification of the participant — for example, in regional programmes that aggregate results across many events — lightweight decentralised verification schemes based on blockchain and computer vision can be layered onto the same mobile platform without disturbing its bring-your-own-device character [14]. The infrastructure that an organising teacher actually needs is reduced to a stable wireless network, a small set of physical training stands or partner workplaces, and a library of pre-recorded reference scenarios stored on a server.

The economics of this configuration are worth stating explicitly. The marginal cost of adding one more participant to a session is essentially zero, since the participant brings their own device. The marginal cost of adding one more profession to the catalogue is the cost of recording and lightly editing a short reference video, which can be done by a partner enterprise with no specialist software. As a result, the total cost of a programme grows almost linearly with the number of distinct professions covered, and almost not at all with the number of students served, which is the inverse of the cost structure that has traditionally constrained career-guidance work.

5.2. Interaction process

The interaction itself unfolds in a manner that participants describe as surprisingly natural. The student stands in front of a training stand or a working area, raises the smartphone or puts on the glasses, and on the screen a step-by-step instruction is superimposed on the real scene in front of them. The eyes do not jump between paper and part: cue and tool sit at the same optical distance, and the gesture suggested by the demonstration is the gesture the participant immediately attempts. Purdue University has confirmed in controlled comparisons that this learning-by-doing format yields levels of comprehension many times higher than those obtained by simply watching the same video on a separate screen. The reason is structural rather than aesthetic: when the demonstration and the action share a common spatial context, the participant does not need to perform the additional cognitive operation of mapping one onto the other, and the cognitive resources thus liberated become available for noticing, for hesitating, and for forming a personal judgement. This structural advantage has been recovered independently in a systematic review of VR and AR applications in vocational education, which associates contextual overlay with the most consistent gains in both affect and performance [15].

5.3. Results

Numbers reported by independent cases such as AVM Technology and SIBUR Digital converge on a consistent picture: motivation among participants rises by approximately forty to fifty per cent compared with conventional career-guidance formats, and the eventual choice of specialty becomes noticeably more deliberate, with fewer participants reporting subsequent regret about their decision. A recent systematic literature review of AR, VR, and intelligent tutoring systems in education and training arrives at a similar aggregate conclusion, highlighting gains in motivation, engagement, and learning outcomes across a wide range of domains [16]. A particularly informative detail comes from the VR4VET project of 2025, which compared virtual and augmented reality in a vocational-orientation setting and ultimately favoured AR. The reason given by the project team is instructive in itself: AR preserves tactile contact with real tools and materials, and without that contact the career-guidance effect noticeably weakens. A purely virtual environment, however immersive, removes precisely the bodily dimension on which informed self-assessment turns out to depend.

It would be premature to treat these figures as definitive. The samples involved are still modest in size, the methodologies of measurement vary across projects, and the long-term effect on actual occupational trajectories will only become visible as the first cohorts of participants enter the labour market. Nonetheless, the convergence of independent results across very different organisational contexts is encouraging, and it suggests that the observed gains reflect a genuine property of the format rather than the enthusiasm of any individual research group.

Conclusion

The technologies of factory-floor augmented reality can in principle be transferred to the practice of career guidance, but they cannot be transferred directly. The goal of the system has to be reformulated: not the flawless execution of an operation but the conscious, embodied acquaintance of a young person with a profession. Once this reformulation is accepted, the well-documented benefits of industrial AR — the relief of working memory, the contraction of training time, the systematic reduction of errors — remain available, but they begin to serve a different end. They no longer optimise productivity; they enable a richer and more honest form of self-encounter.

The core of the proposed model is contextual guidance, in which the reference and the participant's own action coincide in time and space. A passive tour-and-observe visit to an enterprise is replaced by a hands-on trial in which the participant temporarily inhabits the role they are considering. What emerges is a small but genuine fragment of work experience, sufficient to anchor a personal judgement that no amount of secondary description can produce.

The principle of minimal authoring is what makes this approach economically realistic at scale. Scenarios are launched on consumer smartphones, three-dimensional development is dispensed with, and the production of new content can be entrusted to partner enterprises rather than to specialised studios. Scaling such a programme to the level of a region or a country becomes a question of organisation, of agreement among schools and enterprises, and of methodological coordination, rather than a question of capital investment. This is a significant practical consideration, since most previous attempts to bring immersive technologies into mass education have collapsed precisely at the point where capital costs met institutional budgets.

The bottom line can be stated briefly. Augmented reality in career guidance is valuable not for the visual effect it produces on the screen but for the action it compels in the world. It places the young person in the position of someone who is doing the



work rather than someone who is being told about it, and action of this kind is what reliably triggers the process of self-determination. The visuals are a means; the encounter with one's own response to the work is the end.

The natural next step in this line of work is the development of adaptive scenarios that adjust their difficulty on the fly in response to the participant's observed performance, coupled with machine-learning algorithms for the automatic analysis of typical errors. Such an extension would close the loop between the participant's experience and the long-term refinement of the scenario library, allowing the system to become not only a tool for individual self-discovery but also a continuously improving instrument for understanding how young people actually engage with the world of work.

Конфликт интересов

Не указан.

Рецензия

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Conflict of Interest

None declared.

Review

All articles are peer-reviewed. But the reviewer or the author of the article chose not to publish a review of this article in the public domain. The review can be provided to the competent authorities upon request.

Список литературы на английском языке / References in English

1. Verma A. An examination of skill requirements for augmented reality and virtual reality job advertisements / A. Verma, P. Purohit, T. Thornton [et al.] // *Industry and Higher Education*. — 2021. — Vol. 37. — P. 46–57. — DOI: 10.1177/0950422221109104.
2. Shepiliev D. Development of career guidance quests using WebAR / D. Shepiliev, S. Semerikov, Y. Yechkalo [et al.] // *Journal of Physics: Conference Series*. — 2021. — Vol. 1840. — P. 012028. — DOI: 10.1088/1742-6596/1840/1/012028.
3. Rahim M. Development of a career understanding application for elementary school students based on augmented reality / M. Rahim, W. Hulukati, S. Korompot [et al.] // *Jurnal Kependidikan: Jurnal Hasil Penelitian dan Kajian Kepustakaan di Bidang Pendidikan, Pengajaran dan Pembelajaran*. — 2024. — DOI: 10.33394/jk.v10i3.12186.
4. Ariansyah D. Augmented reality training for improved learnability / D. Ariansyah, B. Pardamean, E. Barbaro [et al.] // *CIRP Journal of Manufacturing Science and Technology*. — 2024. — DOI: 10.1016/j.cirpj.2023.11.003.
5. Büttner S. Augmented reality training for industrial assembly work — are projection-based AR assistive systems an appropriate tool for assembly training? / S. Büttner, M. Prilla, C. Röcker // *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems*. — 2020. — DOI: 10.1145/3313831.3376720.
6. Sırakaya M. Effects of augmented reality on student achievement and self-efficacy in vocational education and training / M. Sırakaya, E. Çakmak // *International Journal for Research in Vocational Education and Training*. — 2018. — Vol. 5. — P. 1–18. — DOI: 10.13152/ijrvet.5.1.1.
7. Buchner J. The impact of augmented reality on cognitive load and performance: A systematic review / J. Buchner, K. Buntins, M. Kerres // *Journal of Computer Assisted Learning*. — 2021. — Vol. 38. — P. 285–303. — DOI: 10.1111/jcal.12617.
8. Chan V. VR and AR virtual welding for psychomotor skills: A systematic review / V. Chan, H. Haron, M. Isham [et al.] // *Multimedia Tools and Applications*. — 2022. — Vol. 81. — P. 12459–12493. — DOI: 10.1007/s11042-022-12293-5.
9. Ramadhan M. Augmented reality in vocational education: Trend, acquired skills, and future work / M. Ramadhan, D. Rohendi, M. Handayani [et al.] // *Jurnal Kependidikan: Jurnal Hasil Penelitian dan Kajian Kepustakaan di Bidang Pendidikan, Pengajaran dan Pembelajaran*. — 2024. — DOI: 10.33394/jk.v10i4.12875.
10. Darmawan S. Application of augmented reality (AR) in vocational education: A systematic literature review / S. Darmawan, M. Komaro // *VANOS Journal of Mechanical Engineering Education*. — 2023. — DOI: 10.30870/vanos.v8i2.20841.
11. Acosta J. Framework for designing motivational augmented reality applications in vocational education and training / J. Acosta, S. Navarro, R. Gesa [et al.] // *Australasian Journal of Educational Technology*. — 2019. — DOI: 10.14742/ajet.4182.
12. Caudillo-Melgoza M. Immersive virtual reality experience for informed career decision-making / M. Caudillo-Melgoza, M. Melgoza // *European Conference on Games Based Learning*. — 2025. — DOI: 10.34190/ecgbl.19.1.4139.
13. Korniienko I. Enhancing career adaptability through immersive virtual reality training / I. Korniienko, B. Barchi // *Scientific Bulletin of Mukachevo State University. Series "Pedagogy and Psychology"*. — 2025. — DOI: 10.52534/msu-pp1.2025.41.
14. Uteyev G. Development of the decentralized biometric identity verification system using blockchain technology and computer vision / G. Uteyev, R.F. Gibadullin // *International Research Journal*. — 2024. — № 4 (142). — DOI: 10.23670/IRJ.2024.142.6.
15. Liu Y. A systematic review of VR/AR applications in vocational education: Models, affects, and performances / Y. Liu, Q. Zhan, W. Zhao // *Interactive Learning Environments*. — 2023. — Vol. 32. — P. 6375–6392. — DOI: 10.1080/10494820.2023.2263043.
16. Lampropoulos G. Augmented reality, virtual reality, and intelligent tutoring systems in education and training: A systematic literature review / G. Lampropoulos // *Applied Sciences*. — 2025. — DOI: 10.3390/app15063223.