# BÖLÜM 3

*Doç. Dr. Nuran AKYURT*

# SAĞLIK EĞİTİMİNDE SANAL GERÇEKLİK (VR) VE YAPAY ZEKÂ UYGULAMALARI

DOI: 10.37609/akya.3828.c1614

| Tablo 3.3 Donanım Karşılaştırması | | |
|---|---|---|
| **Özellik** | **IHVR (Bağımsız HMD)** | **CVVR (2D-360° / karton gözlük)** |
| Immersiyon | Yüksek, beceri pratiği için uygun | Sınırlı, farkındalık/bilgi aktarımı |
| Altyapı | Orta (bağımsız HMD veya PC) | Düşük (akıllı telefon yeterli) |
| Ölçeklenebilirlik | Küçük/orta gruplar | Toplum tabanlı, geniş kitle |
| Lojistik | Kurulum/bakım gerekir | Dağıtım kolay, bakım düşük |
| Tipik kullanım | Beceri, kritik adım odaklı eğitim | Tanıtım, bilgilendirme, yaygın erişim |

## KAYNAKLAR


ACOG (2017). *Breast cancer risk assessment and screening in average-risk women* (Practice Bulletin No. 179). American College of Obstetricians and Gynecologists. https://www.acog.org/clinical/clinical-guidance/practice-bulletin/articles/2017/07/breast-cancer-risk-assessment-and-screening-in-average-risk-women

ACR (n. d.). *Mammography positioning review guidelines table*. American College of Radiology. https://learningnetworksupport.acr.org/support/solutions/articles/11000115257-mammography positioning-review-guidelines-table

ACS (2022). *How to prepare for a mammogram*. American Cancer Society. https://www.cancer.org/cancer/types/breast-cancer/screening-tests-and-early-detection/mammograms/mammograms-what-to-know-before-you-go.html

ACS (2023). *Breast cancer screening recommendations*. American Cancer Society. https://www.cancer.org/cancer/types/breast-cancer/screening-tests-and-early-detection/american-cancer-society-recommendations-for-the-early-detection-of-breast-cancer.html

ADL (2016). *Experience API (xAPI) specification* (Version 1.0.3). Advanced Distributed Learning Initiative. https://github.com/adlnet/xAPI-Spec

ADL Initiative (2021). *Overview and application of xAPI, cmi5, and xAPI profiles* [PDF]. Advanced Distributed Learning Initiative. https://www.adlnet.gov/assets/uploads/Overview%20and%20Application%20of%20xAPI%20cmi5%20and%20xAPI%20Profiles.pdf

ADL Initiative (n. d.). *How to Meet WCAG / Quick reference & xAPI resources*. https://www.w3.org/WAI/WCAG22/quickref/

AERA, APA, & NCME (2014). *Standards for educational and psychological testing*. American Educational Research Association.

Akyurt, N. (2018–2021). *Tıbbi Görüntüleme Teknikleri Eğitiminde Sanal Gerçeklik (Proje No: SAG-A-241018-0563)* [Yayımlanmamış bilimsel araştırma projesi raporu].

Akyurt, N. (2023–2025). *Sanal Gerçeklik Teknolojisi (VR) ile Meme Kanseri Erken Tanı ve Tarama Prototifinin Geliştirilmesi (Proje No: ADT-2023-10809, ADEP)* [Yayımlanmamış Ar-Ge projesi raporu].

Baker, R. S., & Inventado, P. S. (2014). Educational data mining and learning analytics. In J. A. Larusson & B. White (Eds.), *Learning analytics: From research to practice* (pp. 61–75). Springer. https://doi.org/10.1007/978-1-4614-3305-7_4

Baniasadi, T., Ayyoubzadeh, S. M., & Mohammadzadeh, N. (2020). Challenges and practical considerations in applying virtual reality in medical education and treatment: A review. *Oman Medical Journal, 35*(3), e125. https://doi.org/10.5001/omj.2020.43

Barteit, S., Lanfermann, L., Bärnighausen, T., Neuhann, F., & Harmsen, J. (2021). Augmented, mixed, and virtual reality–based head-mounted devices for medical education: Systematic review. *JMIR Serious Games, 9*(3), e29080. https://doi.org/10.2196/29080

Beaton, D. E., Bombardier, C., Guillemin, F., & Ferraz, M. B. (2000). Guidelines for the process of cross-cultural adaptation of self-report measures. *Spine, 25*(24), 3186–3191. https://doi.org/10.1097/00007632-200012150-00014

Blair, C., Grehan, A., & Buckley, J. (2021). Immersive 360° videos in health and social care education: A scoping review. *Nurse Education Today, 104*, 105010. https://pubmed.ncbi.nlm.nih.gov/34819063/

Brooke, J. (1996). SUS: A quick and dirty usability scale. In P. W. Jordan, B. Thomas, I. L. McClelland, & B. Weerdmeester (Eds.), *Usability evaluation in industry* (pp. 189–194).

Bu, X., Ng, P. H. F., Xu, W., Cheng, Q., Chen, P. Q., Cheng, A. S. K., et al. (2022). The effectiveness of virtual reality–based interventions in rehabilitation management of breast cancer survivors: Systematic review and meta-analysis. *JMIR Serious Games, 10*(1), e31395. https://doi.org/10.2196/31395

Buche, H., Tourrette, L., & Kalecinski, J. (2022). Use of virtual reality in oncology: From the state of the art to practical proposals. *Frontiers in Virtual Reality, 3*, 894162. https://doi.org/10.3389/frvir.2022.894162

Burrai, F., Sguanci, M., Petrucci, G., De Marinis, M. G., & Piredda, M., et al. (2023). Effectiveness of immersive virtual reality on anxiety, fatigue and pain in patients with cancer undergoing chemotherapy: A systematic review and meta-analysis. *European Journal of Oncology Nursing, 64*, 102340. https://doi.org/10.1016/j.ejon.2023.102340

Caserman, P., Garcia-Agundez, A., Gámez Zerban, A., & Göbel, S. (2021). Cybersickness in current-generation virtual reality head-mounted displays: Systematic review and outlook. *Virtual Reality, 25*(4), 1153–1170. https://doi.org/10.1007/s10055-021-00513-6

Chin, S., Cavadino, A., Akroyd, A., Tennant, G., Dobson, R., & Gautier, A., et al. (2022). An investigation of virtual reality nature experiences in patients with metastatic breast cancer: Secondary analysis of a randomized controlled trial. *JMIR Cancer, 8*, e38300. https://doi.org/10.2196/38300

Corbett, A. T., & Anderson, J. R. (1995). Knowledge tracing: Modeling the acquisition of procedural knowledge. *User Modeling and User-Adapted Interaction, 4*(4), 253–278. https://doi.org/10.1007/BF01099821

Cummings, J. J., & Bailenson, J. N. (2016). How immersive is enough? A meta-analysis of the effect of immersive technology on user presence. *Media Psychology, 19*(2), 272–309. https://doi.org/10.1080/15213269.2015.1015740

Dawe, S. R., Pena, G. N., Windsor, J. A., Broeders, J. A. J. L., Cregan, P. C., Hewett, P. J., & Maddern, G. J. (2014). Systematic review of skills transfer after surgical simulation-based training. *British Journal of Surgery, 101*(9), 1063–1076. https://doi.org/10.1002/bjs.9482

EUREF (2006). *European guidelines for quality assurance in breast cancer screening and diagnosis* (4th ed.).

European Reference Organisation for Quality Assured Breast Screening and Diagnostic Services. https://www.euref.org/european-guidelines

European Parliament & Council (2016). *Regulation (EU) 2016/679 (General Data Protection Regulation)*. EUR-Lex. https://eur-lex.europa.eu/eli/reg/2016/679/oj

European Parliament & Council (2024). *Regulation (EU) 2024/1689 (AI Act)*. EUR-Lex. https://eur-lex.europa.eu/eli/reg/2024/1689/oj

Ferraiolo, D. F., & Kuhn, D. R. (1992). Role-based access controls. In *Proceedings of the 15th National Computer Security Conference* (pp. 554–563). NIST.

Fernandes, A. S., & Feiner, S. K. (2016). Combating VR sickness through subtle dynamic field-of-view modification. [Extended abstract].

Fortune Business Insights (2023). *Virtual reality in healthcare market size, share & industry analysis, by component (hardware, software, services), by application (patient care management, educati-*

*on & training, surgery), and regional forecast, 2023–2030*. https://www.fortunebusinessinsights.com/industry-reports/virtual-reality-vr-in-healthcare-market-101679

Hart, S. G., & Staveland, L. E. (1988). Development of NASA-TLX: Results of empirical and theoretical research. In *Human mental workload* (pp. xx–xx).

Hattie, J., & Timperley, H. (2007). The power of feedback. *Review of Educational Research, 77*(1), 81–112. https://doi.org/10.3102/003465430298487

Hiemstra, E., Kolkman, W., & Dankelman, J. (2011). Technical skills assessment in clinical education: Reliability and validity of OSATS. *Medical Education, 45*(7), 716–723. https://doi.org/10.1111/j.1365-2923.2011.03993.x

Hiemstra, E., Kolkman, W., Wolterbeek, R., Trimbos, B., & Jansen, F.-W. (2011). Value of an objective assessment tool in the operating room. *Canadian Journal of Surgery, 54*(2), 116–122. https://pmc.ncbi.nlm.nih.gov/articles/PMC3116698/

IEEE (2023). *IEEE Standard for eXtensible Learning Record (xAPI) Data Model (IEEE Std 9274.1.1-2023).* https://doi.org/10.1109/IEEESTD.2023.10162485

INACSL Standards Committee (2021). Healthcare Simulation Standards of Best Practice™: Debriefing & Prebriefing. *Clinical Simulation in Nursing*. https://doi.org/10.1016/j.ecns.2020.10.010

Issenberg, S. B., McGaghie, W. C., Petrusa, E. R., Gordon, D. L., & Scalese, R. J. (2005). Features and uses of high-fidelity medical simulations that lead to effective learning: A BEME systematic review. *Medical Teacher, 27*(1), 10–28. https://doi.org/10.1080/01421590500046924

Kennedy, R. S., Lane, N. E., Berbaum, K. S., & Lilienthal, M. G. (1993). Simulator sickness questionnaire: An enhanced method for quantifying simulator sickness. *The International Journal of Aviation Psychology, 3*(3), 203–220. https://doi.org/10.1207/s15327108ijap0303_3

Kişisel Verileri Koruma Kurumu (2016). *Law No. 6698 on the Protection of Personal Data (KVKK).* https://www.kvkk.gov.tr/Icerik/6649/Personal-Data-Protection-Law

Kouijzer, M. M. T. E., Kip, H., Bouman, Y. H. A., & Kelders, S. M. (2023). Implementation of virtual reality in healthcare: A scoping review. *Implementation Science Communications, 4*, 67. https://doi.org/10.1186/s43058-023-00442-2

Kyaw, B. M., Saxena, N., Posadzki, P., Vseteckova, J., Nikolaou, C. K., George, P. P., … Car, J. (2019). Virtual reality for health professions education: Systematic review and meta-analysis by the Digital Health Education Collaboration. *Journal of Medical Internet Research, 21*(1), e12959. https://doi.org/10.2196/12959

Leppink, J., & van den Heuvel, A. (2015). The evolution of cognitive load theory and its application to medical education. *Medical Education, 49*(6), 552–565. https://doi.org/10.1111/medu.12795

Liaw, S. Y., Ooi, S. W., Rusli, K. D. B., Lau, T. C., Tam, W. W. S., & Chua, W. L. (2020). Nurse-physician communication team training in virtual reality versus live simulations: Randomized controlled trial. *Journal of Medical Internet Research, 22*(4), e17279. https://doi.org/10.2196/17279

Lie, S. S., Karlsen, C., Skogås, I. H., Grønning, K., Strand, E., & Solbjør, M. (2023). Implementation of virtual reality in health professions education: Scoping review. *JMIR Medical Education, 9*, e41589. https://doi.org/10.2196/41589

Liu, K., et al. (2023). Effectiveness of virtual reality in nursing education: A systematic review and meta-analysis.

*BMC Medical Education, 23*, 1003. https://doi.org/10.1186/s12909-023-04662-x

Makransky, G., & Lilleholt, L. (2018). A structural equation modeling investigation of the emotional value of immersive virtual reality in education. *Educational Technology Research and Development, 66*(5), 1141–1164. https://doi.org/10.1007/s11423-018-9581-2

Martin, J. A., Regehr, G., Reznick, R., MacRae, H., Murnaghan, J., Hutchison, C., & Brown, M. (1997). Objective structured assessment of technical skill (OSATS) for surgical residents. *British Journal of Surgery, 84*(2), 273–278. https://doi.org/10.1046/j.1365-2168.1997.02502.x

McCoy, C. E., Sayegh, J., Alrabah, R., & Yarris, L. M. (2017). Telesimulation: An innovative tool for health professions education. *AEM Education and Training, 1*(2), 132–136. https://pubmed.ncbi.nlm.nih.gov/30051023/

MedBiquitous (2013). *ANSI/MEDBIQ CI.10.1-2013: Curriculum Inventory Specification*. Association of American Medical Colleges. https://www.medbiq.org/sites/default/files/files/CurriculumInventorySpecification.pdf

MedBiquitous (2018). *MedBiquitous learning activity specification*. Association of American Medical Colleges. https://www.medbiq.org

MedBiquitous Program (n. d.). *Standards & program overview*. Association of American Medical Colleges. https://www.medbiq.org/

Meta Platforms. (n.d.-a). *Locomotion: Comfort & usability*. https://developers.meta.com/horizon/design/locomotion-comfort-usability/

Meta Platforms. (n.d.-b). *Locomotion: User preferences (snap turn vs. smooth turn).* https://developers.meta.com/horizon/design/locomotion-user-preferences/

Melillo, A., Arienti, C., Pirovano, M., Biffi, B., Pizzi, A., & Saita, E., et al. (2022). Virtual reality rehabilitation systems for cancer survivors: A narrative review. *Cancers, 14*(13), 3163. https://doi.org/10.3390/cancers14133163

Messick, S. (1995). Validity of psychological assessment: Validation of inferences from persons' responses. *American Psychologist, 50*(9), 741–749. https://doi.org/10.1037/0003-066X.50.9.741

NHSBSP (n.d.). *Quality assurance guidelines for mammography*. NHS Breast Screening Programme. https://www.gov.uk/government/publications/breast-screening-quality-assurance-guidelines-for-mammography

Niitsu, H., Hirabayashi, N., Yoshimitsu, M., Mimura, T., Takaki, S., & Sugiyama, Y. (2012). Using OSATS for assessment of surgical skills in the operating room setting. *Surgery Today, 42*(3), 255–261. https://doi.org/10.1007/s00595-011-0069-1

NIST (2023). *Artificial Intelligence Risk Management Framework (AI RMF 1.0).* https://doi.org/10.6028/NIST.AI.100-1

Paas, F. G. W. C. (1992). Training strategies for attaining transfer of problem-solving skill in statistics: A cognitive-load approach. *Journal of Educational Psychology, 84*(4), 429–434. https://doi.org/10.1037/0022-0663.84.4.429

Palmisano, S., Mursic, R., & Kim, J. (2020). Cybersickness in head-mounted displays is caused by differences in the virtual and physical head pose (DVP). *Frontiers in Virtual Reality, 1*, 587698. https://doi.org/10.3389/frvir.2020.587698

Pavlik, P. I., Cen, H., & Koedinger, K. R. (2009). Performance Factors Analysis: A new alternative to knowledge tracing. *User Modeling and User-Adapted Interaction, 19*(3), 243–266. https://doi.org/10.1007/s11257-009-9063-7

Pottle, J. (2019). Virtual reality and the transformation of medical education. *Future Healthcare Journal, 6*(3), 181–185. https://doi.org/10.7861/fhj.2019-0036

Reznick, R. K., & MacRae, H. (1997). Teaching surgical skills—Changes in the wind. *The New England Journal of Medicine, 336*(16), 1114–1116. https://doi.org/10.1056/NEJM199704173361611

Sandhu, R. S., Coyne, E. J., Feinstein, H. L., & Youman, C. E. (1996). Role-based access control models. *IEEE Computer, 29*(2), 38–47.

Saredakis, D., Szpak, A., Birckhead, B., Keage, H. A. D., Rizzo, A., & Loetscher, T. (2020). Factors associated with virtual reality sickness in head-mounted displays: A systematic review and meta-analysis. *Frontiers in Human Neuroscience, 14*, 96. https://doi.org/10.3389/fnhum.2020.00096

Shin, J., Chang, J. S., Kim, J. S., An, J. Y., Chung, S. Y., Yoon, S. Y., & Kim, Y. B. (2023). An investigation of the effect of virtual reality on alleviating anxiety in patients with breast cancer undergoing radiation therapy: A randomized controlled trial. *International Journal of Radiation Oncology, Biology, Physics, 117*(5), 1191–1199. https://doi.org/10.1016/j.ijrobp.2023.06.275

Shute, V. J. (2008). Focus on formative feedback. *Review of Educational Research, 78*(1), 153–189. https://doi.org/10.3102/0034654307313795

Slater, M., & Sanchez-Vives, M. V. (2016). Enhancing our lives with immersive virtual reality. *Frontiers in Robotics and AI, 3*, 74. https://doi.org/10.3389/frobt.2016.00074

Slater, M., & Wilbur, S. (1997). A framework for immersive virtual environments. *Presence: Tele-*

*operators and Virtual Environments, 6*(6), 603–616. https://doi.org/10.1162/pres.1997.6.6.603

Slater, M., Usoh, M., & Steed, A. (1994). Depth of presence in virtual environments. *Presence: Teleoperators and Virtual Environments, 3*(2), 130–144. https://doi.org/10.1162/pres.1994.3.2.130

Sung, H., Kim, M., Park, J., Shin, N., & Han, Y. (2024). Effectiveness of virtual reality in healthcare education: Systematic review and meta-analysis. *Sustainability, 16*(19), 8520. https://doi.org/10.3390/su16198520

Sweeney, R.-J., Lewis, S., Hogg, P., & McEntee, M. F. (2017). A review of mammographic positioning image quality criteria for the craniocaudal projection. *The British Journal of Radiology, 91*(1082), 20170611. https://doi.org/10.1259/bjr.20170611

TechNavio (2021). *Global medical education market 2021–2025.* https://www.technavio.com/report/global-medical-education-market-industry-analysis

Thomas, A., Burns, B., Jones, K., … & Hussain, S. (2021). Tips for conducting telesimulation-based medical education. *Cureus, 13*(1), e12421. https://pmc.ncbi.nlm.nih.gov/articles/PMC7854311/

Tsukada, K., Yasui, Y., Miyata, S., et al. (2024). Effectiveness of virtual reality training in teaching personal protective equipment skills: A randomized clinical trial. *JAMA Network Open, 7*(2), e2355358. https://jamanetwork.com/journals/jamanetworkopen/fullarticle/2815073

van Hove, P. D., Tuijthof, G. J., Verdaasdonk, E. G., Stassen, L. P., & Dankelman, J. (2010). Objective assessment of technical surgical skills. *The British Journal of Surgery, 97*(7), 972–987. https://doi.org/10.1002/bjs.7032

VanLehn, K. (2011). The relative effectiveness of human tutoring, intelligent tutoring systems, and other tutoring systems. *Educational Psychologist, 46*(4), 197–221. https://doi.org/10.1080/00461520.2011.611369

Verified Market Research (2024). *Virtual reality in healthcare market size, share & trends analysis report, 2024–2032.* https://www.verifiedmarketresearch.com/product/virtual-reality-in-healthcare-market/

Watershed LRS (n.d.). *What is xAPI?* https://www.watershedlrs.com/resources/definition/what-is-xapi/

Weech, S., Kenny, S., & Barnett-Cowan, M. (2019). Presence and cybersickness in virtual reality are negatively related: A review. *Frontiers in Psychology, 10*, 158. https://doi.org/10.3389/fpsyg.2019.00158

WHO (2020). *Global strategy on digital health 2020–2025.* World Health Organization. https://www.who.int/publications/i/item/9789240020924

Witmer, B. G., & Singer, M. J. (1998). Measuring presence in virtual environments: A presence questionnaire. *Presence: Teleoperators and Virtual Environments, 7*(3), 225–240. https://doi.org/10.1162/105474698565686

Wu, F., Shen, Y., Nguyen, L., & Bowman, D. A. (2022). Adaptive/asymmetric field-of-view restriction to mitigate cybersickness. *Proceedings of the ACM Symposium on Spatial User Interaction (SUI).* DOI: 10.1145/3562939.3565611

xAPI.com (n.d.). *Experience API (xAPI) overview; Tech overview.* https://xapi.com/overview/. https://xapi.com/tech-overview/

Yip, S. H., Ng, A. K. T., Lau, H. Y. K., & Saunders, J. A. (2024). Preregistered test of whether a virtual nose reduces cybersickness. *Cognitive Research: Principles and Implications, 9*, **74**. https://doi.org/10.1186/s41235-024-00593-3