

Supplementary Material

1 SUPPLEMENTARY DATA

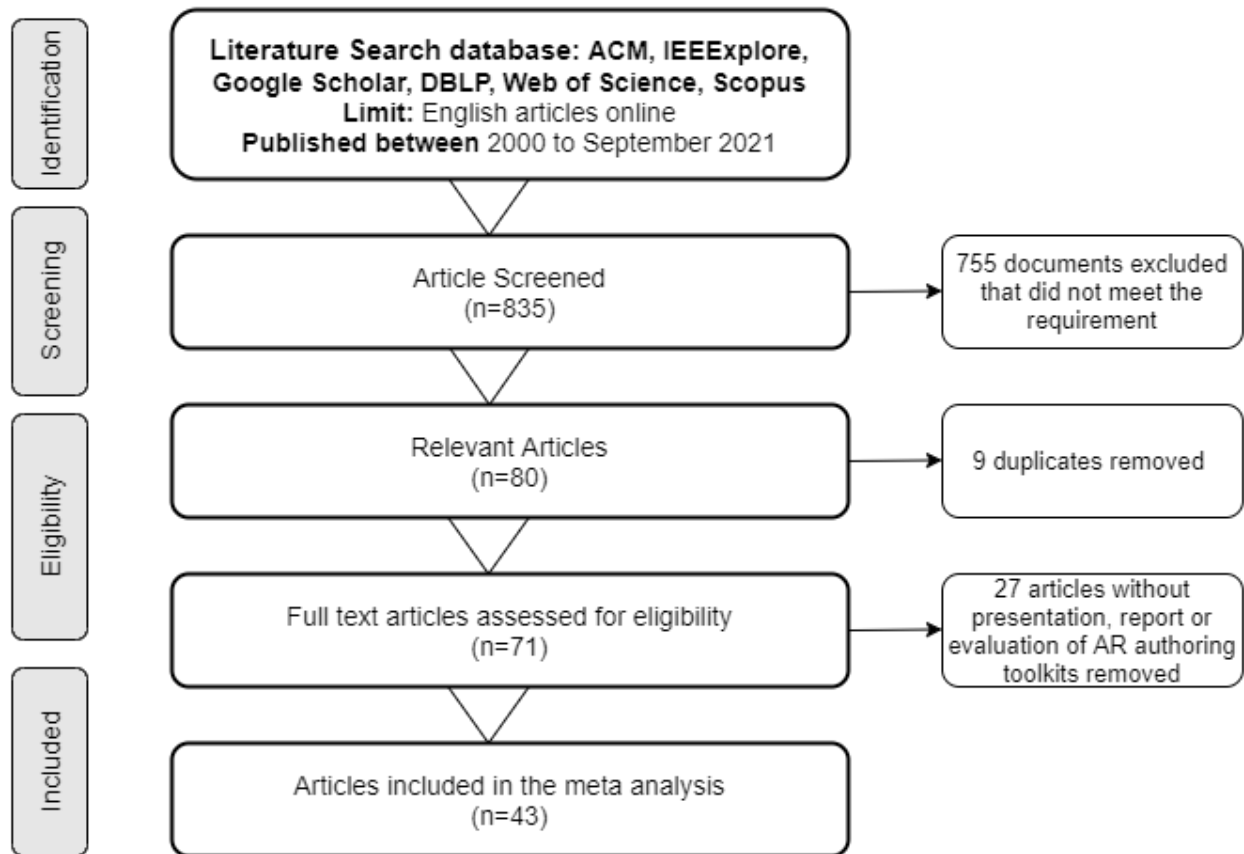


Figure S1. Search Process

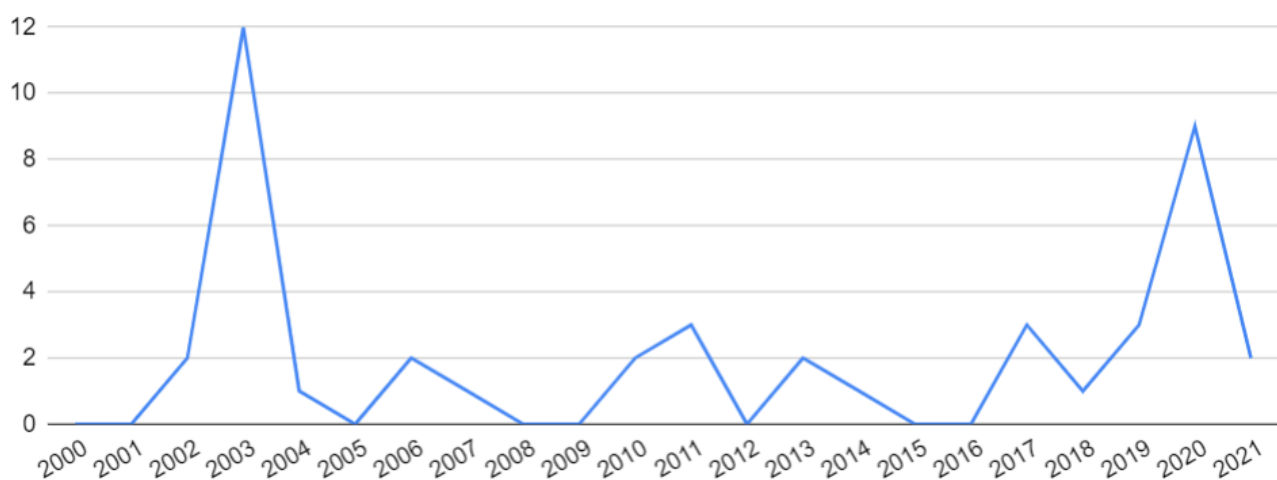


Figure S2. Publication Years of the Selected Articles

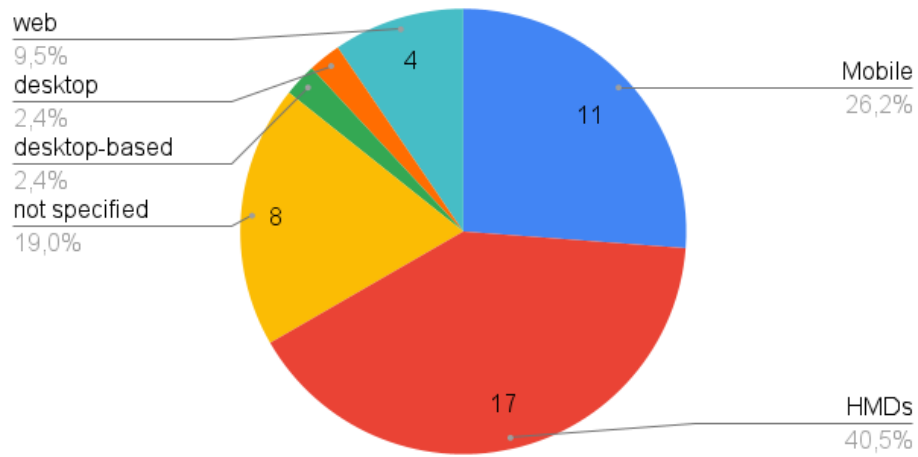


Figure S3. Focused Devices in the Selected Articles

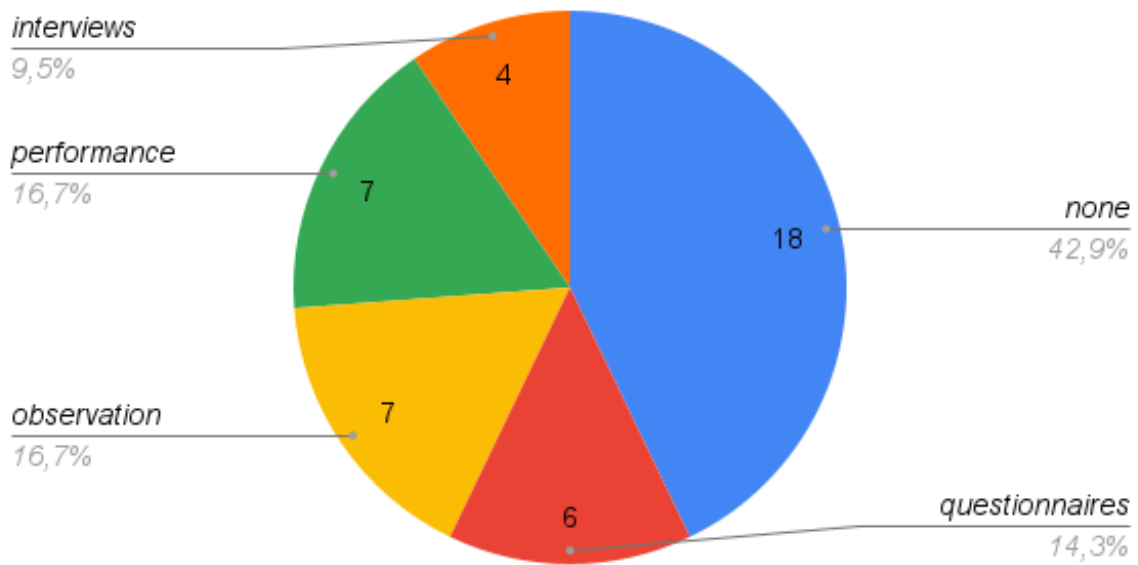


Figure S4. Reported Evaluation Methods for AR Authoring Toolkits

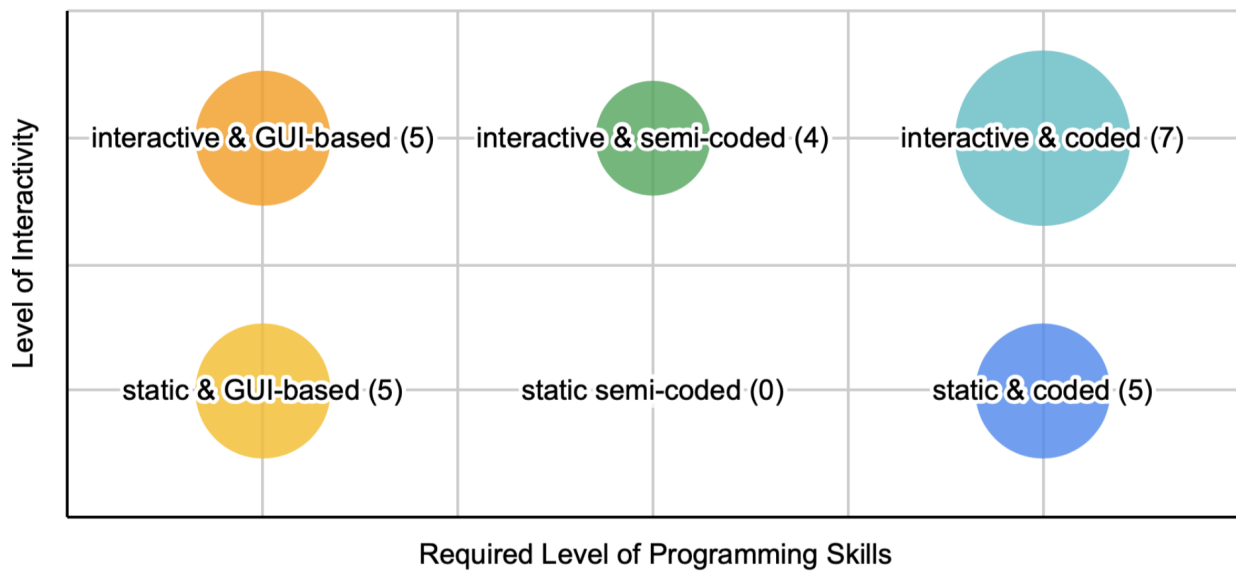


Figure S5. Required Programming Skills and Provided Interaction Possibilities

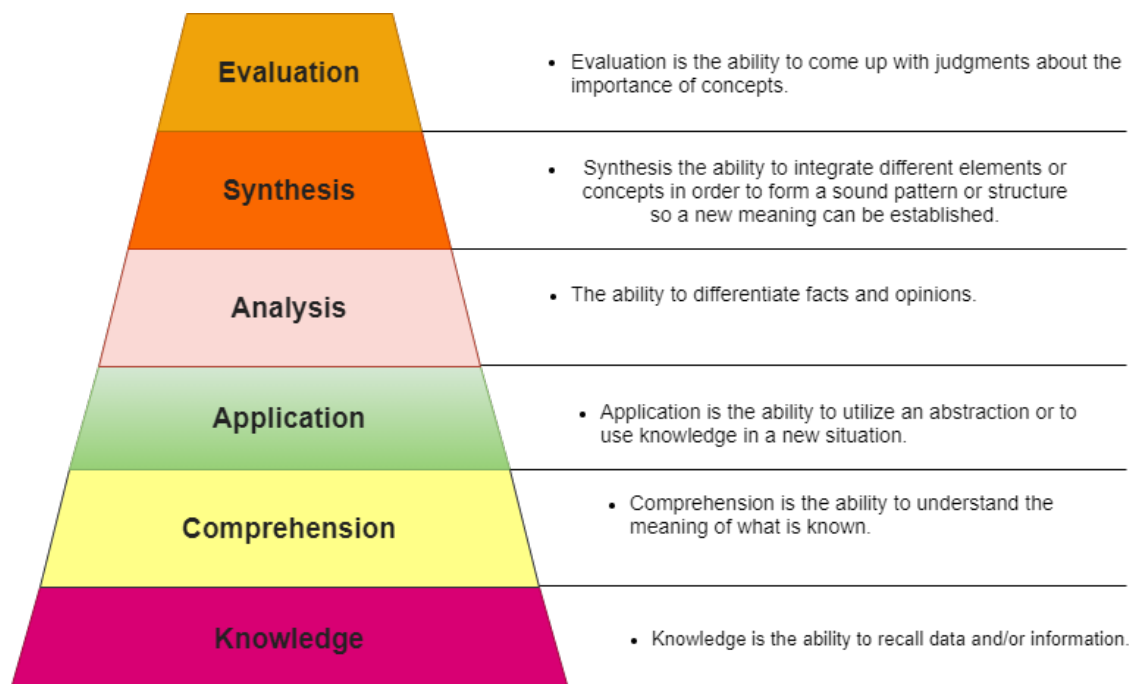


Figure S6. Bloom's Taxonomy with six categories (Anderson and Sosniak, 1994)



Figure S7. Bloom's Taxonomy; From existing work to future goal of the project

<i>Criterion</i>	<i>Inclusion</i>	<i>Exclusion</i>
Time	2000 to 2021	studies before 2000
Language	English	other languages
Type of Article	peer-reviewed research in conference proceedings or journals	other types of documents
Type of Method	studies presenting, using, or evaluating Authoring Toolkits for AR	theoretical articles on AR in general

Table S1. Inclusion and Exclusion Criteria

<i>Toolkit</i>	<i>Programming Skills</i>	<i>Level of Interactivity</i>	<i>Source [Date of Access]</i>
ARToolkit	high	static	ARToolKit (2021)
osgART	high	static	OSGART (2021)
ImageTclAR	medium	dynamic	ImageTcl (2021)
Studierstube	high	dynamic	Studierstube (2021)
DWARF	high	dynamic	Dwarf (2021)
Instant Reality	high	dynamic	InstantReality (2021)
Google Poly	low	static	GooglePoly (2021)
Unity	high	dynamic	Unity (2021)
Unreal Engine	high	dynamic	Engine (2021)
Google ARCore	high	static	ARCore (2021)
ARKit	high	dynamic	ARKit (2021)
Layar	high	static	Layar (2021)
Vuforia Studio	low	dynamic	Vuforia (2021)
Blippar	low	dynamic	Blippar (2021)
Wikitude	high	static	Wikitude (2021)
Metaio	low	static	Metaio (2021)
AWE	low	dynamic	AWE (2021)
AR Media Studio	low	dynamic	Inglobe Technologies (2021)
Spark AR Studio	medium	dynamic	SparkAR (2021)
Snapchat Lens Studio	medium	dynamic	Snap Inc. (2021)
A-Frame	medium	dynamic	A-Frame (2021)
MR Toolkit	high	dynamic	MRToolkit (2021)
DesignAR	low	static	Designar (2021)
MagicBook	low	static	MagicBook (2021)
VEDILS	low	static	Vedils (2021)
Areeka	low	dynamic	Areeka (2021)

Table S2. Accessible AR Authoring Toolkits and Their Characteristics

<i>Toolkit</i>	<i>Academic Source</i>	<i>Toolkit Type</i>	<i>Citation Count</i>
ARToolkit	Kato (2007)	static & GUI-based	34
osgART	Looser et al. (2006)	static & GUI-based	102
ImageTclAR	Owen et al. (2003)	interactive & semi-coded	41
Studierstube	Schmalstieg et al. (2002)	interactive & coded	622
DWARF	Bauer et al. (2001)	interactive & coded	310
Balcisoy	Balcisoy et al. (2000)	interactive & coded	61
iaTAR	Lee et al. (2004)	static & coded	223
K-MART	Choi et al. (2010)	static & coded	14
Google Poly	Crawford et al. (2020)	interactive & coded	0
Unity	Kim et al. (2014)	interactive & coded	110
ARScratch	Radu and MacIntyre (2009)	interactive & GUI-based	51
Unreal Engine	Sanders (2016)	static & GUI-based	49
Google ARCore	Lanham (2018)	interactive & coded	33
Layar	Liao and Humphreys (2015)	static & GUI-based	111
Vuforia Studio	Simonetti Ibanez (2013)	interactive & GUI-based	44
BuildAR	Looser (2010)	interactive & GUI-based	1
Spark AR Studio	Spark (2019)	interactive & semi-coded	4
PoseMMR	Pan and Mitchell (2020b)	static & GUI-based	3
Tiles	Poupyrev et al. (2001)	interactive & semi-coded	111
HoloBuilder	Speicher et al. (2015)	interactive & semi-coded	11
MR Toolkit	Dias et al. (2003b)	interactive & coded	16
DesignAR	Reipschläger and Dachsel (2019)	static & coded	28
MagicBook	Billinghurst et al. (2001)	static & coded	645
VEDILS	Mota et al. (2016)	static & coded	24
Areeka	Buchner and Jeghiazaryan (2020)	interactive & GUI-based	3

Table S3. Academic references to AR Authoring Toolkits , Toolkit Types and citations count

<i>Toolkit</i>	<i>Affordability Free/Commercial licence</i>	<i>Device Compatibility (Web, HMDs, Desktop PC, Smartphones)</i>	<i>Collaboration Capacity (Yes/NO)</i>
ARToolKit (2021)	Free	Smartphone, Desktop	No
OSGART (2021)	Free	Smartphone, Desktop	No
ImageTcl (2021)	Free	Desktop	No
Studierstube (2021)	Free	HMDs	Yes
Dwarf (2021)	Free	HMDs	No
InstantReality (2021)	Free	Desktop, Smartphone	No
GooglePoly (2021)	Free	Web	No
Layar (2021)	Commercial	Smartphone	No
Vuforia (2021)	Free/Commercial	Web, Smartphone, Desktop	No
Blippar (2021)	Free	Smartphone, Web	No
Wikitude (2021)	Commercial	Web, Smartphone, Desktop	Yes
Metaio (2021)	Free	Web, Smartphone, Desktop	No
AWE (2021)	Free	Web	No
Inglobe Technologies (2021)	Free/Commercial	Smartphone	No
SparkAR (2021)	Free	smartphone	No
Snap Inc. (2021)	Free	smartphone	No
A-Frame (2021)	Free	Web, Smartphone, Desktop	No
MRToolkit (2021)	Free	Web, Smartphone, Desktop	No
Designar (2021)	Free/Commercial	Mobile Web	No
MagicBook (2021)	Free	HMDs	Yes
Vedils (2021)	Free	Smartphone	No
Areeka (2021)	Free/Commercial	Web	No
StoryCreatAR (2021)	Free	HMDs	Yes
Ediphy (2020)	Free	Web	No
Kim et al. (2020)	Free	Smartphone	No
AuthorAR (2013)	Free	Desktop PC	No
ARgent (2020)	Free	Web	No
AugmentedBook (2019)	Free	Smartphone	No
MAGIS (2019)	Free	Smartphone	No
FI-AR (2019)	Free	Web	Yes
BlocklyXR (2021)	Free	Web	Yes

Table S4. Analysis of Authoring Tools according to Affordability (Cost), Device Compatibility, Collaboration Capacity

APPENDIX A

Articles after the Screening Phase

<i>Year</i>	<i>Author</i>	<i>Title</i>	<i>Project</i>	<i>Included</i>
2002	Wagner and Regenbrecht	Shared Reality Meeting -a Collaborative Augmented Reality Environment	Shared Reality Meeting	No
	Haller et al.	Combining ARToolkit with Scene Graph Libraries	AMIRE	Yes
	Grimm et al.	AMIRE -Authoring Mixed Reality	AMIRE	Yes
2003	MacIntyre et al.	DART: the Designer's Augmented Reality Toolkit	DART	Yes
	Dias et al.	Developing and Authoring Mixed Reality with MX Toolkit	MX Toolkit	Yes
	Seichter	Collaborative Augmented Sketching	Augmented Reality in Architecture	Yes
	Dias et al.	Usability Evaluation of Tangible User Interfaces for Augmented Reality	MixIt	Yes
	Adcock et al.	Augmented Reality Haptics: Using ARToolkit for Display of Haptic Applications	-	Yes
	Henrysson and Ollila	Augmented Reality on Smartphones	-	No
	Reimann et al.	Object-Oriented Toolkit for Augmented Reality	OO-ARToolkit	Yes
	Wagner and Loew	Configuration Strategies of an AR Toolkit-based Wide Area Tracker	ARCHIE	Yes
	Woolard et al.	Using ARToolkit to Prototype Future Entertainment Scenarios	-	Yes
	Pintaric	An Adaptive Thresholding Algorithm for the Augmented Reality Toolkit	-	Yes
	Kato et al.	MagicCup: A Tangible Interface for Virtual Objects Manipulation in Table-Top Augmented Reality	MagicCup	Yes
	Kato et al.	A Registration Method based on Texture Tracking using ARToolkit	-	Yes
	DiVerdi et al.	A Framework for Generic Inter-Application Interaction for 3D AR Environments	-	Yes

2004	Ledermann	An Authoring Framework for Augmented Reality Presentations	APRIL	Yes
	Lee et al.	Immersive authoring of tangible augmented reality applications	-	Yes
2006	Chaudhary	Surgery needs HPC, Really!	CASMIL	Yes
	Gandy et al.	Supporting Early Design Activities for AR Experiences	DART	Yes
2007	Santos et al.	CINeSPACE: Interactive Access to Cultural Heritage While On-The-Move	CINeSPACE	Yes
2008	Read	Jabberwocky: Children's Digital Ink Story Writing from Nonsense to Sense	-	No
2010	Wang et al.	An Easy to Use Augmented Reality Authoring Tool for Use in Examination Purpose	-	Yes
	Li	Augmented Reality for Remote Education	ARERE	Yes
2011	Shim et al.	MSL_AR Toolkit: AR Authoring Tool with Interactive Features	MSL_AR Toolkit	Yes
	Park	AR-Room: a rapid prototyping framework for augmented reality applications	AR-Room	Yes
	Pessoa et al.	RPR-SORS: Real-time photorealistic rendering of synthetic objects into real scenes	RPR-SORS	Yes
	Silva et al.	Words Game in an Educational Context Augmented Reality Application	-	No
	Wongwatkit et al.	A Development of Augmented Reality Application: AR BAND	AR BAND	No
	Jee et al.	An immersive authoring tool for augmented reality-based e-learning applications	-	Yes
2012	FitzGerald et al.	Augmented reality and mobile learning: the state of the art	-	No (Review)
2013	Barbadillo and Sánchez	A Web3D Authoring Tool for Augmented Reality Mobile Applications	Web3D AR Authoring Tool	Yes

	Nincarean et al.	Mobile Augmented Reality: the potential for education	-	No (Review)
	Lucrecia et al.	AuthorAR: Authoring tool for building educational activities based on Augmented Reality	AuthorAR	Yes
2014	Gandy and MacIntyre	Designer's Augmented Reality Toolkit, Ten Years Later: Implications for New Media Authoring Tools	DART	Yes
	Boyko and Funkhouser	Cheaper by the Dozen: Group Annotation of 3D Data	IGRA	No
	Latoschik and Stuerzlinger	On the Art of the Evaluation and Presentation of RIS-Engineering	-	No
2015	Mota et al.	Authoring Tools in Augmented Reality: An Analysis and Classification of Content Design Tools	-	No (Review)
2017	Packer et al.	Developing a Writer's Toolkit for Interactive Locative Storytelling	StoryPlaces	No
	Kampa	Authoring Concepts and Tools for Interactive Digital Storytelling in the Field of Mobile Augmented Reality	SPIRIT	Yes
	de Paiva Guimarães et al.	Embedding Augmented Reality Applications into Learning Management Systems	-	No
	Li et al.	A State-of-the-Art Review of Augmented Reality in Engineering Analysis and Simulation	-	Yes
	Vert and Andone	A State-of-the-Art Zero-programming augmented reality authoring tools for educators: Status and recommendations	-	No (Review)
2018	Jo et al.	VR Planning Toolkit to Simulate Physical and Virtual Configurations: A Case Study of an Indoor VR Roller Coaster Augmenting Experience	-	No
	Wheeler et al.	Virtual interaction and visualisation of 3D medical imaging data with VTK and Unity	-	Yes
	Nebeling and Speicher	The Trouble with Augmented Reality/Virtual Reality Authoring Tools	-	No (Review)
2019	Saykili	Augmented Reality in Open and Distance Learning	-	No (Review)

Yusoff et al.	A Systematic Literature Review of Augmented Reality Applications in Libraries	-	No (Review)
Coma-Tatay et al.	FI-AR learning: a web-based platform for augmented reality educational content	FI-AR learning	Yes
Vidal Jr et al.	MAGIS: mobile augmented-reality games for instructional support	MAGIS	Yes
Alzahrani and Lajmi	AugmentedBook: A Collaborative E-Learning Augmented Reality Platform	AugmentedBook	Yes
Pan and Mitchell	Group-Based Expert Walkthroughs: How Immersive Technologies Can Facilitate the Collaborative Authoring of Character Animation	PoseMMR	Yes
Whitlock et al.	MRCAT: In Situ Prototyping of Interactive AR Environments	MRCAT	Yes
Dinechin and Paljic	Demonstrating COLIBRI VR, an Open-Source Toolkit to RenderReal-World Scenes in Virtual Reality	-	No
Dinechin and Paljic	From Real to Virtual: An Image-Based Rendering Toolkit to Help Bring the World Around Us Into Virtual Reality	-	No
Takala et al.	Martial Arts Training in Virtual Reality with Full-body Tracking and Physically Simulated Opponents	-	No
de Dinechin and Paljic	Presenting COLIBRI VR, an Open-Source Toolkit to Render Real-World Scenes in Virtual Reality	-	No
de Dinechin and Paljic	Illustrating COLIBRI VR, an Open-Source Toolkit to Render Real-World Scenes in Virtual Reality	-	No
Benbelkacem et al.	MVC-3DC: Software architecture model for designing collaborative augmented reality and virtual reality systems	-	No
Freitas et al.	A Systematic Review of Rapid Prototyping Tools for Augmented Reality	-	No (Review)
Kljun et al.	Augmented Reality in Education: Current Status and Advancement of the Field	-	No (Review)

Villanueva et al.	Meta-AR-App: An Authoring Platform for Collaborative Augmented Reality in STEM Classrooms	Meta-AR-App	Yes
Pan and Mitchell	PoseMMR: A Collaborative Mixed Reality Authoring Tool for Character Animation	PoseMMR	Yes
Ashtari et al.	Creating Augmented and Virtual Reality Applications: Current Practices, Challenges, and Opportunities	-	No (Review)
Bégout et al.	WAAT: a Workstation AR Authoring Tool for Industry 4.0	WAAT	Yes
López-Pernas et al.	Ediphy: A modular and extensible open-source web authoring tool for the creation of interactive learning resources	Ediphy	Yes
Gökhan and Gökhan	ARgent: A Web Based Augmented Reality Framework for Dynamic Content Generation	ARgent	Yes
Kim et al.	An AR contents Authoring Tool with Remote Monitoring by Contextual Information	-	Yes
Singh et al.	Story CreatAR: a Toolkit for Spatially-Adaptive Augmented Reality Storytelling	Story CreatAR	Yes
Jung et al.	BlocklyXR: An Interactive Extended Reality Toolkit for Digital Storytelling	BlocklyXR	Yes

APPENDIX B

<i>Toolkit</i>	<i>Accessible</i>	<i>Toolkit</i>	<i>Accessible</i>
ARToolkit	Yes	Authoring Wizard	No
osgART	Yes	CDT1; CDT2; CDT3	No
DART	No	VR Editor	No
composAR	No	ARBookCreator	No
AMIRE	No	AVATAR	No
MSL_AR Toolkit	No	Tiles	Yes
SceneCTRL	No	Facebook Spark AR Studio	Yes
AR-Room	No	Snapchat Lens Studio	No
ImageTclAR	Yes	HoloBuilder	Yes
MR Platform	No	A-Frame	No
Coterie	No	ProtoAR	No
Studierstube	Yes	Web3D AR Authoring Tool	No
DWARF	Yes	ATOMIC	No
Balcisoy	Yes	FLARAS	No
Instant Reality	No	MR Toolkit	Yes
SOMOD	No	ARTag	No
iaTAR	Yes	MX Toolkit	No
Google Poly	Yes	Interface for Examination	No
Unity	Yes	360proto	No
Unreal Engine	Yes	ARtalet	No
Google ARCore	Yes	DesignAR	Yes
Apple ARKit	No	MagicBook	Yes
Meta-AR-App	No	MARS	No
Layar	Yes	APRIL	No
Vuforia Studio	Yes	ACARS	No
Blippar	Yes	SUGAR	No
PoseMMR	Yes	ARAUM	No
Wikitude Studio	No	VEDILS	Yes
k-MART	Yes	HARATIO	No
Metaio Creator	No	AR Mobile Authoring Tool	No
AR Scratch	Yes	Smartphone AR Authoring Tool	No
Powerspace	No	WAAT	No
Build AR	Yes	Areeka	Yes
AR Media Plugin	No		

REFERENCES

- A-Frame, 2021. Installation – a-frame. <https://aframe.io/docs/1.2.0/introduction/installation.html>. Accessed on 04/19/2021.
- Adcock, M., Hutchins, M., Gunn, C., 2003. Augmented reality haptics: using artoolkit for display of haptic applications, in: 2003 IEEE International Augmented Reality Toolkit Workshop, pp. 1–2. doi:10.1109/ART.2003.1320415.
- Alzahrani, N.M., Lajmi, S., 2019. Augmentedbook: A collaborative e-learning augmented reality platform, in: International Conference on Human Interaction and Emerging Technologies, Springer. pp. 282–288.
- Anderson, L.W., Sosniak, L.A., 1994. Bloom’s taxonomy. Univ. Chicago Press Chicago, IL.
- ARCore, 2021. <https://developers.google.com/ar/develop>. Accessed on 04/19/2021.
- Areeka, 2021. Webar areeka studio. <https://studio.areeka.net/#/>. Accessed on 04/19/2021.
- ARgent, 2020. Argent: A web based augmented reality framework for dynamic content generation. *Avrupa Bilim ve Teknoloji Dergisi*, 244–257.
- ARKit, 2021. Arkit overview. <https://developer.apple.com/augmented-reality/arkit/>. Accessed on 04/19/2021.
- ARToolKit, 2021. Artoolkit download. <http://www.hitl.washington.edu/artoolkit/download/>. Accessed on 04/19/2021.
- Ashtari, N., Bunt, A., McGrenere, J., Nebeling, M., Chilana, P.K., 2020. Creating augmented and virtual reality applications: Current practices, challenges, and opportunities, in: Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems, Association for Computing Machinery, New York, NY, USA. p. 1–13. URL: <https://doi.org/10.1145/3313831.3376722>, doi:10.1145/3313831.3376722.
- AugmentedBook, 2019. Augmentedbook: A collaborative e-learning augmented reality platform.
- AuthorAR, 2013. Authorar: Authoring tool for building educational activities based on augmented reality.
- AWE, 2021. Create webar with awe (augmented web experiences). <https://awe.media/#main>. Accessed on 04/19/2021.
- Balcisoy, S., Kallmann, M., Fua, P., Thalmann, D., 2000. A framework for rapid evaluation of prototypes with augmented reality, in: Proceedings of the ACM symposium on Virtual reality software and technology, pp. 61–66.
- Barbadillo, J., Sánchez, J.R., 2013. A web3d authoring tool for augmented reality mobile applications, in: Proceedings of the 18th International Conference on 3D Web Technology, Association for Computing Machinery, New York, NY, USA. p. 206. URL: <https://doi.org/10.1145/2466533.2466564>, doi:10.1145/2466533.2466564.
- Bauer, M., Bruegge, B., Klinker, G., MacWilliams, A., Reicher, T., Riss, S., Sandor, C., Wagner, M., 2001. Design of a component-based augmented reality framework, in: Proceedings IEEE and ACM International Symposium on Augmented Reality, IEEE. pp. 45–54.
- Benbelkacem, S., Zenati, N., Aouam, D., Izountar, Y., Otmame, S., 2019. Mvc-3dc: Software architecture model for designing collaborative augmented reality and virtual reality systems. *Journal of King Saud University - Computer and Information Sciences* 32. doi:10.1016/j.jksuci.2019.11.010.
- Billinghurst, M., Kato, H., Poupyrev, I., 2001. The magicbook: a transitional ar interface. *Computers & Graphics* 25, 745–753.
- Blippar, 2021. Augmented reality (ar) & computer vision company — blippar. <https://www.blippar.com/>. Accessed on 04/19/2021.
- BlocklyXR, 2021. Blocklyxr: An interactive extended reality toolkit for digital storytelling.

- Boyko, A., Funkhouser, T., 2014. Cheaper by the dozen: Group annotation of 3d data, in: *Proceedings of the 27th Annual ACM Symposium on User Interface Software and Technology*, Association for Computing Machinery, New York, NY, USA. p. 33–42. URL: <https://doi.org/10.1145/2642918.2647418>, doi:10.1145/2642918.2647418.
- Buchner, J., Jeghiazaryan, A., 2020. Work-in-progress—the ari 2 ve model for augmented reality books, in: *2020 6th International Conference of the Immersive Learning Research Network (iLRN)*, IEEE. pp. 287–290.
- Bégout, P., Duval, T., Kubicki, S., Charbonnier, B., Bricard, E., 2020. WAAT: A Workstation AR Authoring Tool for Industry 4.0. pp. 304–320. doi:10.1007/978-3-030-58468-9_22.
- Chaudhary, V., 2006. Surgery needs hpc, really!, in: *2006 International Conference on Parallel Processing Workshops (ICPPW'06)*, pp. 1 pp.–418. doi:10.1109/ICPPW.2006.71.
- Choi, J., Kim, Y., Lee, M., Kim, G.J., Nam, Y., Kwon, Y., 2010. k-mart: Authoring tool for mixed reality contents, in: *2010 IEEE International Symposium on Mixed and Augmented Reality*, IEEE. pp. 219–220.
- Coma-Tatay, I., Casas-Yrurzum, S., Casanova-Salas, P., Fernández-Marín, M., 2019. Fi-ar learning: a web-based platform for augmented reality educational content. *Multimedia Tools and Applications* 78, 6093–6118.
- Crawford, S., Monks, S., Luevano, E., Urbina, J., 2020. Virtual reality scenario design for distance learning with google poly. Available at SSRN 3802155 .
- Designar, 2021. Designar - build ar experiences for your online store. <https://www.designar.io/>. Accessed on 04/19/2021.
- Dias, J., Monteiro, L., Santos, P., Silvestre, R., Bastos, R., 2003a. Developing and authoring mixed reality with mx toolkit, in: *2003 IEEE International Augmented Reality Toolkit Workshop*, pp. 18–26. doi:10.1109/ART.2003.1320420.
- Dias, J.M.S., Monteiro, L., Santos, P., Silvestre, R., Bastos, R., 2003b. Developing and authoring mixed reality with mx toolkit, in: *2003 IEEE International Augmented Reality Toolkit Workshop*, IEEE. pp. 18–26.
- Dias, M., Jorge, J., Carvalho, J., Santos, P., Luzio, J., 2003c. Usability evaluation of tangible user interfaces for augmented reality, in: *2003 IEEE International Augmented Reality Toolkit Workshop*, pp. 54–61. doi:10.1109/ART.2003.1320428.
- de Dinechin, G.D., Paljic, A., 2020a. Illustrating colibri vr, an open-source toolkit to render real-world scenes in virtual reality, in: *2020 IEEE Conference on Virtual Reality and 3D User Interfaces Abstracts and Workshops (VRW)*, pp. 856–856. doi:10.1109/VRW50115.2020.00280.
- de Dinechin, G.D., Paljic, A., 2020b. Presenting colibri vr, an open-source toolkit to render real-world scenes in virtual reality, in: *2020 IEEE Conference on Virtual Reality and 3D User Interfaces Abstracts and Workshops (VRW)*, pp. 800–801. doi:10.1109/VRW50115.2020.00251.
- Dinechin, G.D.d., Paljic, A., 2020a. Demonstrating colibri vr, an open-source toolkit to render real-world scenes in virtual reality, in: *2020 IEEE Conference on Virtual Reality and 3D User Interfaces Abstracts and Workshops (VRW)*, pp. 844–845. doi:10.1109/VRW50115.2020.00273.
- Dinechin, G.D.d., Paljic, A., 2020b. From real to virtual: An image-based rendering toolkit to help bring the world around us into virtual reality, in: *2020 IEEE Conference on Virtual Reality and 3D User Interfaces Abstracts and Workshops (VRW)*, pp. 348–353. doi:10.1109/VRW50115.2020.00076.
- DiVerdi, S., Nurmi, D., Hollerer, T., 2003. A framework for generic inter-application interaction for 3d ar environments, in: *2003 IEEE International Augmented Reality Toolkit Workshop*, pp. 86–93. doi:10.1109/ART.2003.1320436.

- Dwarf, 2021. Dwarf install tutorial. <http://campar.in.tum.de/Chair/DwarfInstallTutorial>. Accessed on 04/19/2021.
- Edify, 2020. Edify: A modular and extensible open-source web authoring tool for the creation of interactive learning resources.
- Engine, U., 2021. Unreal engine. <https://www.unrealengine.com/en-US/download>. Accessed on 04/19/2021.
- FI-AR, 2019. Fi-ar learning: a web-based platform for augmented reality educational content.
- FitzGerald, E., Adams, A., Ferguson, R., Gaved, M., Mor, Y., Thomas, R., 2012. Augmented reality and mobile learning: the state of the art, in: 11th World Conference on Mobile and Contextual Learning (mLearn 2012), pp. 62–69. URL: <http://oro.open.ac.uk/34281/>. published in CEUR Workshop Proceedings, Volume 955, pp. 62-69. This volume is published and copyrighted by its editors. Copying permitted only for private and academic purposes.
- Freitas, G., Pinho, M.S., Silveira, M.S., Maurer, F., 2020. A systematic review of rapid prototyping tools for augmented reality, in: 2020 22nd Symposium on Virtual and Augmented Reality (SVR), IEEE. pp. 199–209.
- Gandy, M., MacIntyre, B., 2014. Designer’s augmented reality toolkit, ten years later: Implications for new media authoring tools, in: Proceedings of the 27th Annual ACM Symposium on User Interface Software and Technology, Association for Computing Machinery, New York, NY, USA. p. 627–636. URL: <https://doi.org/10.1145/2642918.2647369>, doi:10.1145/2642918.2647369.
- Gandy, M., Macintyre, B., Dow, S., Bolter, J., 2006. Supporting Early Design Activities for AR Experiences. doi:10.4018/9781599040660.ch008.
- Gökhan, K., Gökhan, İ., 2020. Argent: A web based augmented reality framework for dynamic content generation. *Avrupa Bilim ve Teknoloji Dergisi* , 244–257.
- GooglePoly, 2021. Poly. <https://poly.google.com/>. Accessed on 04/19/2021.
- Grimm, P., Haller, M., Paelke, V., Reinhold, S., Reimann, C., Zauner, R., 2002. Amire - authoring mixed reality, in: The First IEEE International Workshop Augmented Reality Toolkit., pp. 2 pp.–. doi:10.1109/ART.2002.1107008.
- Haller, M., Hartmann, W., Luckeneder, T., Zauner, J., 2002. Combining artoolkit with scene graph libraries, in: The First IEEE International Workshop Augmented Reality Toolkit., pp. 2 pp.–. doi:10.1109/ART.2002.1106978.
- Henrysson, A., Ollila, M., 2003. Augmented reality on smartphones, in: 2003 IEEE International Augmented Reality Toolkit Workshop, pp. 27–28. doi:10.1109/ART.2003.1320421.
- ImageTcl, 2021. Imagetcl multimedia development system. <https://web.archive.org/web/20100410200411/http://metlab.cse.msu.edu/imagetcl/>. Accessed on 04/19/2021.
- Inglobe Technologies, 2021. Ar-media downloads. <https://www.inglobetechnologies.com/ar-media/downloads/>. Accessed on 04/19/2021.
- InstantReality, 2021. instantreality.org. <https://www.instantreality.org/downloads/>. Accessed on 04/19/2021.
- Jee, H.K., Lim, S., Youn, J., Lee, J., 2011. An immersive authoring tool for augmented reality-based e-learning applications, in: 2011 International Conference on Information Science and Applications, IEEE. pp. 1–5.
- Jo, D., Kim, Y., Jeon, W., Kim, Y., Kim, H., Kim, K.H., Kwak, S., 2018. Vr planning toolkit to simulate physical and virtual configurations: A case study of an indoor vr roller coaster augmenting experience, in: Proceedings of the 9th Augmented Human International Conference, Association for Computing Machinery, New York, NY, USA. URL: <https://doi.org/10.1145/3174910.3174912>,

- doi:10.1145/3174910.3174912.
- Jung, K., Nguyen, V.T., Lee, J., 2021. Blocklyxr: An interactive extended reality toolkit for digital storytelling. *Applied Sciences* 11, 1073.
- Kampa, A., 2017. Authoring concepts and tools for interactive digital storytelling in the field of mobile augmented reality, in: Nunes, N., Oakley, I., Nisi, V. (Eds.), *Interactive Storytelling*, Springer International Publishing, Cham. pp. 372–375.
- Kato, H., 2007. Inside artoolkit, in: 1st IEEE International Workshop on Augmented Reality Toolkit.
- Kato, H., Tachibana, K., Billinghurst, M., Grafe, M., 2003a. A registration method based on texture tracking using artoolkit, in: 2003 IEEE International Augmented Reality Toolkit Workshop, pp. 77–85. doi:10.1109/ART.2003.1320435.
- Kato, H., Tachibana, K., Tanabe, M., Nakajima, T., Fukuda, Y., 2003b. Magiccup: a tangible interface for virtual objects manipulation in table-top augmented reality, in: 2003 IEEE International Augmented Reality Toolkit Workshop, pp. 75–76. doi:10.1109/ART.2003.1320434.
- Kim, J., Lee, B.g., Jung, S.U., 2020. An ar contents authoring tool with remote monitoring by contextual information, in: 2020 IEEE International Conference on Consumer Electronics-Asia (ICCE-Asia), IEEE. pp. 1–3.
- Kim, S.L., Suk, H.J., Kang, J.H., Jung, J.M., Laine, T.H., Westlin, J., 2014. Using unity 3d to facilitate mobile augmented reality game development, in: 2014 IEEE World Forum on Internet of Things (WF-IoT), IEEE. pp. 21–26.
- Kljun, M., Geroimenko, V., Pucihar, K., 2020. Augmented Reality in Education: Current Status and Advancement of the Field. pp. 3–21. doi:10.1007/978-3-030-42156-4_1.
- Lanham, M., 2018. *Learn ARCore-Fundamentals of Google ARCore: Learn to build augmented reality apps for Android, Unity, and the web with Google ARCore 1.0*. Packt Publishing Ltd.
- Latoschik, M.E., Stuerzlinger, W., 2014. On the art of the evaluation and presentation of ris-engineering, in: 2014 IEEE 7th Workshop on Software Engineering and Architectures for Realtime Interactive Systems (SEARIS), pp. 9–17. doi:10.1109/SEARIS.2014.7152796.
- Layar, 2021. Solutions — layar. <https://www.layar.com/solutions/>. Accessed on 04/19/2021.
- Ledermann, F., 2004. An authoring framework for augmented reality presentations.
- Lee, G.A., Nelles, C., Billinghurst, M., Kim, G.J., 2004. Immersive authoring of tangible augmented reality applications, in: Third IEEE and ACM International Symposium on Mixed and Augmented Reality, IEEE. pp. 172–181.
- Li, W., Nee, A.Y.C., Ong, S.K., 2017. A state-of-the-art review of augmented reality in engineering analysis and simulation. *Multimodal Technologies and Interaction* 1. URL: <https://www.mdpi.com/2414-4088/1/3/17>, doi:10.3390/mti1030017.
- Li, Y., 2010. Augmented reality for remote education, in: 2010 3rd International Conference on Advanced Computer Theory and Engineering(ICACTE), pp. V3–187–V3–191. doi:10.1109/ICACTE.2010.5579661.
- Liao, T., Humphreys, L., 2015. Layar-ed places: Using mobile augmented reality to tactically reengage, reproduce, and reappropriate public space. *New Media & Society* 17, 1418–1435.
- Looser, J., 2010. *Making augmented reality accessible for everyone*. New Zeland: Human Interface Technology Laboratory New Zealand .
- Looser, J., Grasset, R., Seichter, H., Billinghurst, M., 2006. Osgart-a pragmatic approach to mr .
- López-Pernas, S., Jiménez, A., Gordillo, A., Barra, E., Marco, L., Quemada, J., 2020. Ediphy: A modular and extensible open-source web authoring tool for the creation of interactive learning resources, in: 2020

- 16th International Conference on Intelligent Environments (IE), IEEE. pp. 115–121.
- Lucrecia, M., Cecilia, S., Patricia, P., Sandra, B., 2013. Authorar: Authoring tool for building educational activities based on augmented reality, in: 2013 international conference on collaboration technologies and systems (cts), IEEE. pp. 503–507.
- MacIntyre, B., Gandy, M., Bolter, J., Dow, S., Hannigan, B., 2003. Dart: the designer's augmented reality toolkit, in: The Second IEEE and ACM International Symposium on Mixed and Augmented Reality, 2003. Proceedings., pp. 329–330. doi:10.1109/ISMAR.2003.1240744.
- MagicBook, 2021. Magicbook 4d - ar learning – apps bei google play. <https://play.google.com/store/apps/details?id=com.firecoals.magicbook.magicalanimal>. Accessed on 04/19/2021.
- MAGIS, 2019. Magis: mobile augmented-reality games for instructional support.
- Metaio, 2021. Metaio creator - free download and software reviews - cnet download. <https://download.cnet.com/Metaio-Creator/3000-6675-4-75861515.html>. Accessed on 04/19/2021.
- Mota, J.M., Ruiz-Rube, I., Dodero, J.M., Figueiredo, M., 2016. Visual environment for designing interactive learning scenarios with augmented reality. International Association for Development of the Information Society .
- Mota, R.C., Roberto, R.A., Teichrieb, V., 2015. [poster] authoring tools in augmented reality: An analysis and classification of content design tools, in: 2015 IEEE International Symposium on Mixed and Augmented Reality, pp. 164–167. doi:10.1109/ISMAR.2015.47.
- MRTToolkit, 2021. Github - microsoft/mixedrealitytoolkit-unity: Mixed reality toolkit (mrtk) provides a set of components and features to accelerate cross-platform mr app development in unity. <https://github.com/microsoft/MixedRealityToolkit-Unity>. Accessed on 04/19/2021.
- Nebeling, M., Speicher, M., 2018. The trouble with augmented reality/virtual reality authoring tools, in: 2018 IEEE International Symposium on Mixed and Augmented Reality Adjunct (ISMAR-Adjunct), pp. 333–337. doi:10.1109/ISMAR-Adjunct.2018.00098.
- Nincarean, D., Alia, M.B., Halim, N.D.A., Rahman, M.H.A., 2013. Mobile augmented reality: The potential for education. Procedia - Social and Behavioral Sciences 103, 657–664. URL: <http://www.sciencedirect.com/science/article/pii/S1877042813038305>, doi:<https://doi.org/10.1016/j.sbspro.2013.10.385>. 13th International Educational Technology Conference.
- OSGART, 2021. Osgart: Artoolkit for openscenegraph. <https://artoolworks.com/community/osgart/download.html>. Accessed on 04/19/2021.
- Owen, C., Tang, A., Xiao, F., 2003. Imagetclar: A blended script and compiled code development system for augmented reality, in: Proceedings of the International Workshop on Software Technology for Augmented Reality Systems, Citeseer. pp. 537–544.
- Packer, H.S., Hargood, C., Howard, Y., Papadopoulos, P., Millard, D.E., 2017. Developing a writer's toolkit for interactive locative storytelling, in: Nunes, N., Oakley, I., Nisi, V. (Eds.), Interactive Storytelling, Springer International Publishing, Cham. pp. 63–74.
- de Paiva Guimarães, M., Alves, B., Martins, V.F., dos Santos Baglie, L.S., Brega, J.R., Dias, D.C., 2017. Embedding augmented reality applications into learning management systems, in: Gervasi, O., Murgante, B., Misra, S., Borruso, G., Torre, C.M., Rocha, A.M.A., Tanar, D., Apduhan, B.O., Stankova, E., Cuzzocrea, A. (Eds.), Computational Science and Its Applications – ICCSA 2017, Springer International Publishing, Cham. pp. 585–594.

- Pan, Y., Mitchell, K., 2020a. Group-based expert walkthroughs: How immersive technologies can facilitate the collaborative authoring of character animation, in: 2020 IEEE Conference on Virtual Reality and 3D User Interfaces Abstracts and Workshops (VRW), pp. 188–195. doi:10.1109/VRW50115.2020.00041.
- Pan, Y., Mitchell, K., 2020b. Posemmr: a collaborative mixed reality authoring tool for character animation, in: 2020 IEEE Conference on Virtual Reality and 3D User Interfaces Abstracts and Workshops (VRW), IEEE. pp. 758–759.
- Park, J.S., 2011. Ar-room: A rapid prototyping framework for augmented reality applications. *Multimedia Tools Appl.* 55, 725–746. URL: <https://doi.org/10.1007/s11042-010-0592-1>, doi:10.1007/s11042-010-0592-1.
- Pessoa, S.A., de S. Moura, G., do M. Lima, J.P.S., Teichrieb, V., Kelner, J., 2012. Rpr-sors: Real-time photorealistic rendering of synthetic objects into real scenes. *Computers Graphics* 36, 50–69. URL: <https://www.sciencedirect.com/science/article/pii/S0097849311001701>, doi:<https://doi.org/10.1016/j.cag.2011.12.003>. virtual Reality in Brazil 2011.
- Pintaric, T., 2003. An adaptive thresholding algorithm for the augmented reality toolkit, in: 2003 IEEE International Augmented Reality Toolkit Workshop, pp. 71–. doi:10.1109/ART.2003.1320431.
- Poupyrev, I., Tan, D., Billingham, M., Kato, H., Regenbrecht, H., Tetsutani, N., 2001. Tiles: A mixed reality authoring interface, in: (2001) INTERACT 2001 Conference on Human Computer Interaction.
- Radu, I., MacIntyre, B., 2009. Augmented-reality scratch: a children's authoring environment for augmented-reality experiences, in: Proceedings of the 8th International Conference on Interaction Design and Children, pp. 210–213.
- Read, J.C., 2008. Jabberwocky: Children's digital ink story writing from nonsense to sense, in: Proceedings of the 3rd International Conference on Digital Interactive Media in Entertainment and Arts, Association for Computing Machinery, New York, NY, USA. p. 85–90. URL: <https://doi.org/10.1145/1413634.1413654>, doi:10.1145/1413634.1413654.
- Reimann, C., Engel, S., Paelke, V., 2003. Object-oriented toolkit for augmented reality, in: 2003 IEEE International Augmented Reality Toolkit Workshop, pp. 32–34. doi:10.1109/ART.2003.1320423.
- Reipschläger, P., Dachsel, R., 2019. Designar: Immersive 3d-modeling combining augmented reality with interactive displays, in: Proceedings of the 2019 ACM International Conference on Interactive Surfaces and Spaces, pp. 29–41.
- Sanders, A., 2016. An introduction to Unreal engine 4. CRC Press.
- Santos, P., Stork, A., Linaza, M.T., Machui, O., McIntyre, D., Jorge, E., 2007. Cinespace: Interactive access to cultural heritage while on-the-move, in: Schuler, D. (Ed.), *Online Communities and Social Computing*, Springer Berlin Heidelberg, Berlin, Heidelberg. pp. 435–444.
- Saykili, A., 2019. Augmented reality in open and distance learning. doi:10.20472/TEC.2019.008.024.
- Schmalstieg, D., Fuhrmann, A., Hesina, G., Szalavári, Z., Encarnação, L.M., Gervautz, M., Purgathofer, W., 2002. The studierstube augmented reality project. *Presence: Teleoperators & Virtual Environments* 11, 33–54.
- Seichter, H., 2003. Collaborative augmented sketching, in: 2003 IEEE International Augmented Reality Toolkit Workshop, pp. 42–43. doi:10.1109/ART.2003.1320425.
- Shim, J., Seo, J., Han, T.d., 2011. Msl.ar toolkit: Ar authoring tool with interactive features, in: Shumaker, R. (Ed.), *Virtual and Mixed Reality - New Trends*, Springer Berlin Heidelberg, Berlin, Heidelberg. pp. 105–112.

- Silva, V.C.d., Goes Jr., E.S.d., França, M.d.H., Ambrósio, P.E., 2011. Words game in an educational context: Augmented reality application, in: *Proceedings of the 2011 XIII Symposium on Virtual Reality*, IEEE Computer Society, USA. p. 128–133. URL: <https://doi.org/10.1109/SVR.2011.38>, doi:10.1109/SVR.2011.38.
- Simonetti Ibanez, A.e.a., 2013. Vuforia v1. 5 SDK: Analysis and evaluation of capabilities. Master's thesis. Universitat Politècnica de Catalunya.
- Singh, A., Kaur, R., Haltner, P., Peachey, M., Gonzalez-Franco, M., Malloch, J., Reilly, D., 2021. Story creator: a toolkit for spatially-adaptive augmented reality storytelling, in: *2021 IEEE Virtual Reality and 3D User Interfaces (VR)*, IEEE. pp. 713–722.
- Snap Inc., 2021. Download - lens studio by snap inc. <https://lensstudio.snapchat.com/download/>. Accessed on 04/19/2021.
- Spark, A., 2019. Studio.
- SparkAR, 2021. Spark ar studio. <https://sparkar.facebook.com/ar-studio/download/>. Accessed on 04/19/2021.
- Speicher, M., Tenhaft, K., Heinen, S., Handorf, H., 2015. Enabling industry 4.0 with holobuilder. *INFORMATIK 2015*.
- StoryCreatAR, 2021. Story creator: a toolkit for spatially-adaptive augmented reality storytelling.
- Studierstube, 2021. Studierstube download. <https://www.heise.de/download/product/studierstube-68048>. Accessed on 04/19/2021.
- Takala, T.M., Hirao, Y., Morikawa, H., Kawai, T., 2020. Martial arts training in virtual reality with full-body tracking and physically simulated opponents, in: *2020 IEEE Conference on Virtual Reality and 3D User Interfaces Abstracts and Workshops (VRW)*, pp. 858–858. doi:10.1109/VRW50115.2020.00282.
- Unity, 2021. Unity store. <https://store.unity.com/download>. Accessed on 04/19/2021.
- Vedils, 2021. Vedils - visual environment for designing interactive learning scenarios. <http://vedils.uca.es/web/techDrawing.html>. Accessed on 04/19/2021.
- Vert, S., Andone, D., 2017. Zero-programming augmented reality authoring tools for educators: Status and recommendations, in: *2017 IEEE 17th international conference on advanced learning technologies (ICALT)*, IEEE. pp. 496–498.
- Vidal Jr, E.C.E., Ty, J.F., Caluya, N.R., Rodrigo, M.M.T., 2019. Magis: mobile augmented-reality games for instructional support. *Interactive Learning Environments* 27, 895–907.
- Villanueva, A., Zhu, Z., Liu, Z., Peppler, K., Redick, T., Ramani, K., 2020. Meta-ar-app: An authoring platform for collaborative augmented reality in stem classrooms, in: *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems*, Association for Computing Machinery, New York, NY, USA. p. 1–14. URL: <https://doi.org/10.1145/3313831.3376146>, doi:10.1145/3313831.3376146.
- Vuforia, 2021. Vuforia developer portal. <https://developer.vuforia.com/downloads/sdk>. Accessed on 04/19/2021.
- Wagner, M., Loew, F., 2003. Configuration strategies of an ar toolkit-based wide area tracker, in: *2003 IEEE International Augmented Reality Toolkit Workshop*, pp. 62–68. doi:10.1109/ART.2003.1320429.
- Wagner, M., Regenbrecht, H., 2002. Shared reality meeting - a collaborative augmented reality environment, in: *The First IEEE International Workshop Augmented Reality Toolkit*, pp. 2 pp.–. doi:10.1109/ART.2002.1106970.
- Wang, M.J., Tseng, C.H., Shen, C.Y., 2010. An easy to use augmented reality authoring tool for use in examination purpose, in: *Forbrig, P., Paternó, F., Mark Pejtersen, A. (Eds.), Human-Computer Interaction*, Springer Berlin Heidelberg, Berlin, Heidelberg. pp. 285–288.

- Wheeler, G., Deng, S., Toussaint, N., Pushparajah, K., Schnabel, J., Simpson, J., Gomez, A., 2018. Virtual interaction and visualisation of 3d medical imaging data with vtk and unity. *Healthcare Technology Letters* 5. doi:10.1049/htl.2018.5064.
- Whitlock, M., Mitchell, J., Pfeufer, N., Arnot, B., Craig, R., Wilson, B., Chung, B., Szafir, D.A., 2020. Mrcat: In situ prototyping of interactive ar environments, in: Chen, J.Y.C., Fragomeni, G. (Eds.), *Virtual, Augmented and Mixed Reality. Design and Interaction*, Springer International Publishing, Cham. pp. 235–255.
- Wikitude, 2021. World leading augmented reality engine - download overview. <https://www.wikitude.com/download/>. Accessed on 04/19/2021.
- Wongwatkit, C., Lertkulvanich, S., Sirimayurachat, K., Sawasdee, T., Sae-Er, W., 2011. A development of augmented reality application: Ar band. doi:10.1115/1.859926.paper24.
- Woolard, A., Lalioti, V., Hedley, N., Julien, J., Hammond, M., Carrigan, N., 2003. Using artoolkit to prototype future entertainment scenarios, in: *2003 IEEE International Augmented Reality Toolkit Workshop*, pp. 69–70. doi:10.1109/ART.2003.1320430.
- Yusoff, R.C.M., Osman, A., Shariff, S.A., Hassan, N.H., Sjarif, N.N.A., Ibrahim, R., Zainuddin, N.M., Maarop, N., 2019. A systematic literature review of augmented reality applications in libraries, in: Saeed, F., Gazem, N., Mohammed, F., Busalim, A. (Eds.), *Recent Trends in Data Science and Soft Computing*, Springer International Publishing, Cham. pp. 1037–1046.