Identification of Design Recommendation for Augmented Reality Authors in Corporate Training

Stefan Graser (MSc) | Dr. Martin Schrepp | Prof. Dr. Stephan Böhm

*30th September 2025, CENTRIC, Lisbon, Portugal | Paper **30011***

RESUME

Innovative technologies, such as Augmented Reality (AR), introduce new interaction paradigms, demanding the identification of software requirements during the software development process. In general, design recommendations are related to this, supporting the design of applications positively and meeting stakeholder needs. However, current research lacks context-specific AR design recommendations. This study addresses this gap by identifying and analyzing practical AR design recommendations relevant to the evaluation phase of the User-Centered Design (UCD) process. We rely on an existing dataset of Mixed Reality (MR) design recommendations. We applied a multi-method approach by (1) extending the dataset with AR-specific recommendations published since 2020, (2) classifying the identified recommendations using a NLP classification approach based on a pre-trained Sentence Transformer model, (3) summarizing the content of all topics, and (4) evaluating their relevance concerning AR in Corporate Training (CT) both based on a qualitative Round Robin approach with five experts. As a result, an updated dataset of 597 practitioner design recommendations, classified into 84 topics, is provided with new insights into their applicability in the context of AR in CT. Based on this, 32 topics with a total of 284 statements were evaluated as relevant for AR in CT. This research directly contributes to the authors' work for extending their AR-specific User Experience (UX) measurement approach, supporting AR authors in targeting the improvement of AR applications for CT scenarios.

Keywords– *Augmented Reality (AR); Software Requirements Engineering; AR Design Recommendations; Corporate Training (CT); Natural Language Processing (NLP); Semantic Textual Similarity (STS); Sentence Transformers (SBERT).*

AGENDA

1. **Introduction & Related Research**
2. Methodology
3. Results
4. Conclusion

AUGMENTED REALITY IN CORPORATE TRAINING

RheinMain University of Applied Sciences

> *Augmented Reality (AR) allows the user to see the real world, with virtual objects superimposed upon or composited with the real world. Therefore,* ***AR supplements reality****, rather than completely replacing.* *(Azuma 1997)*

- High potential of AR for improving training and education in the corporate environment. *(Billinghurst & Dünser 2012, Dirin & Laine 2018, Chang et al. 2020, Criollo-C et al. 2021)*
  - // capturing and experiencing learning content in a new way.
  - // **multimodality** and **interactivity** in learning.
  - // improvement of learner engagement, motivation, and effectiveness.

- **AR authoring** describes the process of application development
  - // refers to the interdisciplinary field of software engineering
  - // software requirements elicitation as an initial step
  - // AR Authors = developers and designers (different roles)

→ **Requirements are the basis for system design & development.**

DESIGN RECOMMENDATIONS

RheinMain University of Applied Sciences

- Design recommendations provide an **orientation** in the form of **standards** and **best practices**

  // crucial role in efficiently designing usable interactive technologies in an early stage

  // recommendations include *design principles*, *guidelines*, and *heuristics*

- Not all requirements must be determined each time

  // existing **design practices** and **lessons learned** over time

  // resulting in various recorded design recommendations

- Applying general design recommendations (from other contexts) risks **neglecting new interaction paradigms** from innovative technologies

Application domain-specific recommendations are essential for developing and designing new technologies

AUGMENTED REALITY DESIGN RECOMMENDATIONS

RheinMain University of Applied Sciences

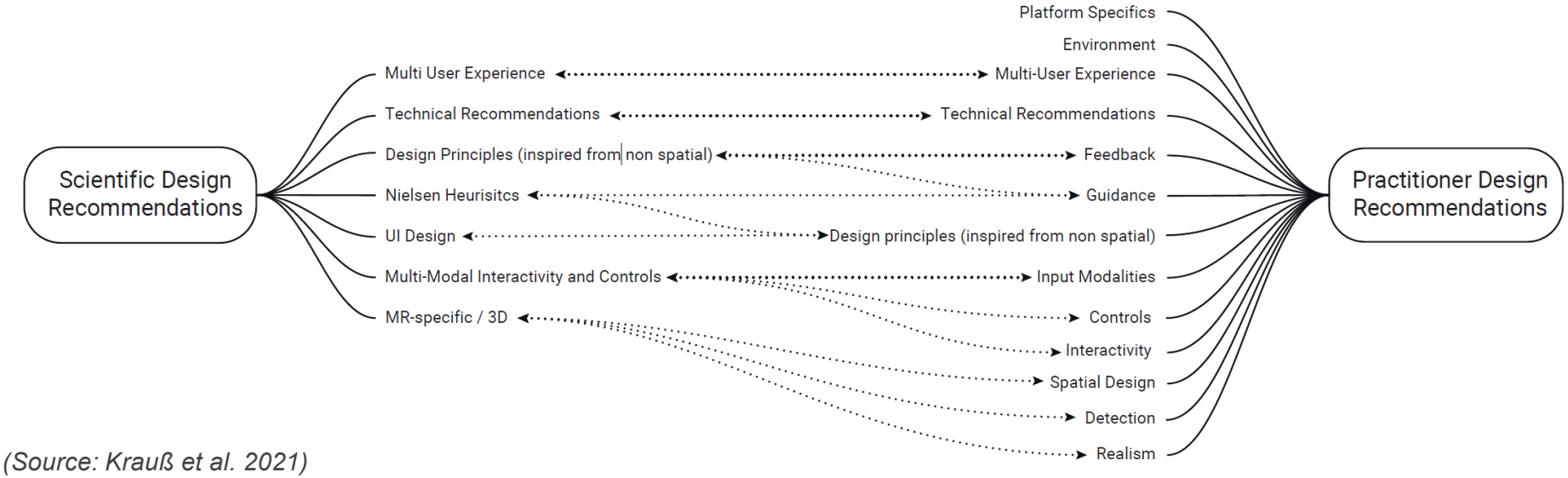
Investigation of existing AR design recommendations by Krauß et al. (2021)

// extensive literature review

// based on 89 scientific publications and documentation from industry companies actively developing MR hardware and software

// more than 2000 statements classified in main categories and topics based on similarity

// differentiation between practitioner design recommendations (PDRs) and scientific design recommendations (SDRs)



(Source: Krauß et al. 2021)

AUGMENTED REALITY DESIGN RECOMMENDATIONS

RheinMain University of Applied Sciences

- Insights regarding design recommendations based on Krauß et al. (2021):
  - // research often applies **traditional** (non-spatial) UI principles
  - // AR-specific design recommendations are **hard to find**, **inconsistent**, and often **irrelevant**
  - // different abstraction levels of PDRs (more specific) and SDRs (highly abstract and generic)
  - // weak empirical base

- Since 2020, little research has been conducted on AR design recommendations
  - // most papers adopt existing recommendations and apply them to a specific use case
  - // three research articles apply existing recommendations to the field of CT
  - // only two articles could be identified proposing new recommendations

→ **Existing recommendations need to be further (1) analyzed, (2) structured, and (3) classified for better access, use, and communication regarding Corporate Training**

PRACTICAL DESIGN RECOMMENDATIONS

RheinMain University of Applied Sciences

Dataset with **504 statements** classified in **84 topics** and **13 main categories**.

Exemplary excerpt of the dataset by Krauß et al. (2021):

Statements (= design recommendations)	Topic	Main Category	Device	Source
Setting limits on your objects and making sure they can't be sized too large or small is important.	**Object Scaling**	Interactivity	HMD	Magic Leap
Generally, always keep target areas at a minimum finger width. It is not always clear to users that objects will scale relative to the environment, and therefore when objects move back into the distance they perceive it as scaling and not moving	**Object Scaling**	Interactivity	HH / HMD	IBM
Avoid auto-rotating an object unless it's an intentional part of the experience. Persistent autorotation can be disconcerting for users.	**Object Rotating**	Interactivity	HH	Google
Rotating a virtual object lets the user orient the object's position in any direction. Objects can be rotated either manually or automatically.	**Object Rotating**	Interactivity	HH	Google

RESEARCH OBJECTIVE & QUESTIONS

RheinMain University of Applied Sciences

Identification of AR-specific design recommendations for the field of CT

(1) What practical AR-specific design recommendations exist?

(2) How can the resulting topics be summarized and communicated?

(3) Which topics are particularly important for the AR application domain of Corporate Training?

RheinMain University of Applied Sciences

AGENDA

1. Introduction & Related Research
2. **Methodology**
3. Results
4. Conclusion

STUDY APPROACH

RheinMain University of Applied Sciences

We applied a **multi-method approach** containing **four research steps**:

(1) Identification of AR design recommendations
based on a review

↓

(2) Semantic topic classification of new AR design recommendations
based on a NLP approach

↓

(3) Content summarization of AR design recommendation topics
based on a qualitative Round Robin approach with AR authors

↓

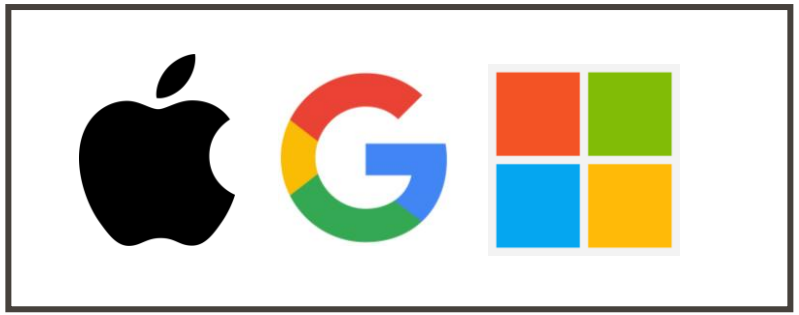
(4) Evaluation of relevant topics concerning AR in CT
based on a qualitative Round Robin approach with AR authors

(1) IDENTIFICATION OF AR DESIGN RECOMMENDATIONS

RheinMain University of Applied Sciences

Analysis of the six market-leading industry companies, following the procedure by Krauß et al. (2021)

Focus on AR-specific PDRs



(2) SEMANTIC TOPIC CLASSIFICATION

RheinMain University of Applied Sciences

Application of the pretrained sentence transformer model **SBERT** for Semantic Textual Similarity (STS)-based **text classification**

all-mpnet-base-v2 model

Topic 1
Statement 1
Statement 2
…

Topic 2
Statement 1
Statement 2
…

(1) Comparison

Newly identified statements

(2) Classification*

to the respective topic with the **highest similarity score*

(3) & (4) TOPIC SUMMARIZATION AND EVALUATION

RheinMain University of Applied Sciences

Qualitative **Round Robin approach** with five domain experts*

- **Split** of topics into five lists *(1-17, 18-34, …)*
- **Five-round evaluation** with the same task
- Each expert had the task of analyzing and summarizing all statements of each topic in each round
- Evaluation of the relevance of the respective topic concerning CT based on a Content Validity Index (CVI)

	Expert (1)	Expert (2)	Expert (3)	Expert (4)	Expert (5)
Round (1)	1-17	18 - 34	35 - 51	52 - 68	69 - 84
Round (2)	18 - 34	35 - 51	52 - 68	69 - 84	1-17
Round (3)	35 - 51	52 - 68	69 - 84	1-17	18 - 34
Round (4)	52 - 68	69 - 84	1-17	18 - 34	35 - 51
Round (5)	69 - 84	1-17	18 - 34	35 - 51	52 - 68

*Experts:

- *3 AR authors **from research***
- *1 AR author from **practice***
- *1 senior consultant in UX **design and software requirements engineering***

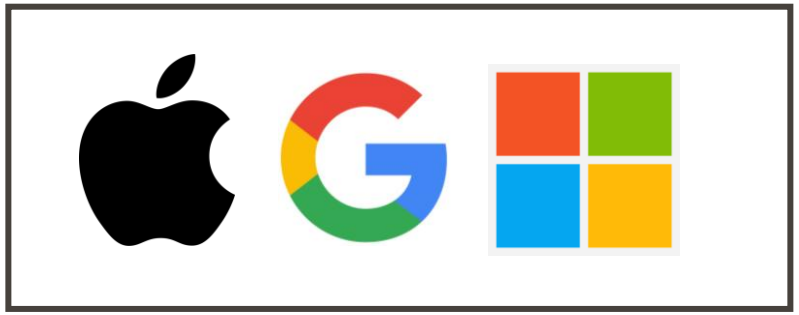
RheinMain University of Applied Sciences

AGENDA

1. Introduction & Related Research
2. Methodology
3. **Results**
4. Conclusion

(1) IDENTIFICATION OF AR DESIGN RECOMMENDATIONS

RheinMain University of Applied Sciences



No new statements since 2020

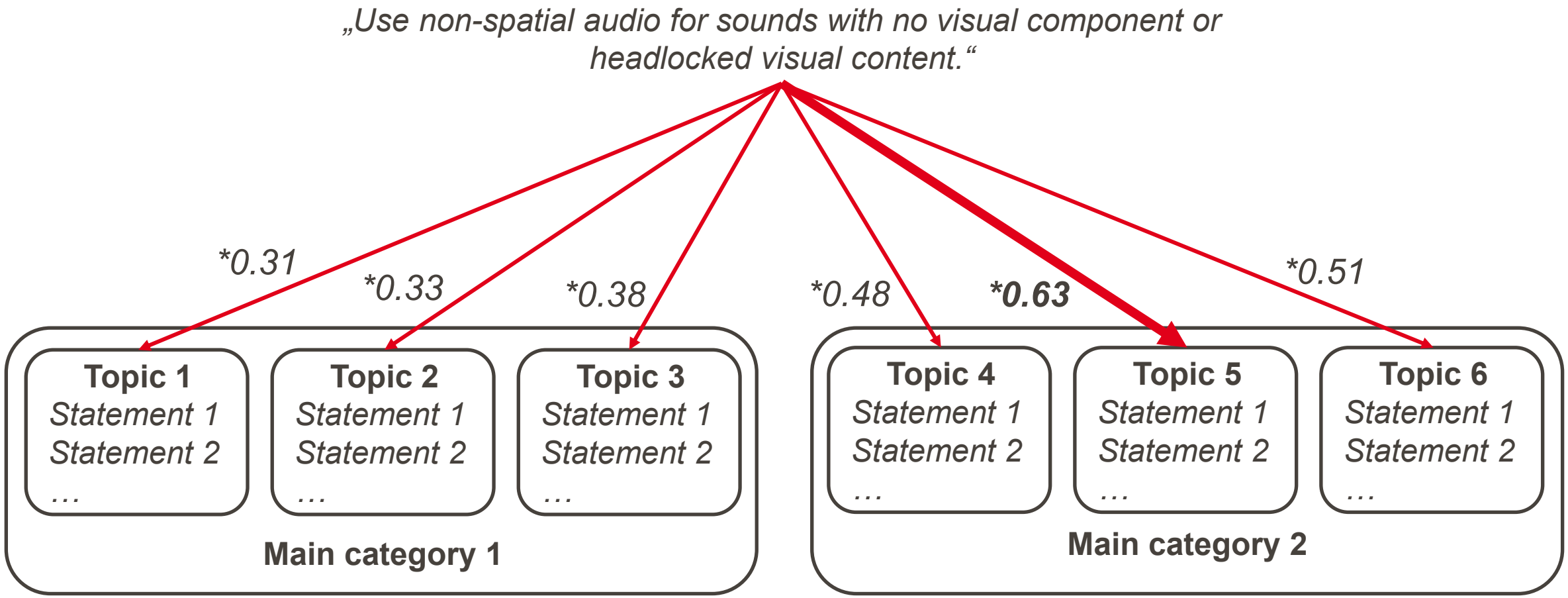
93 new statements since 2020

Work on AR **discontinued**

Resulting in a total of 504 statements classified in 84 topics

(2) SEMANTIC TOPIC CLASSIFICATION

The 93 new statements were classified into **26 topics**, grouped under **9 main categories**. The cosine similarity score* values range between **0.26** and **0.69**.



(3) & (4) TOPIC SUMMARIZATION AND EVALUATION

RheinMain University of Applied Sciences

Applying the **Content Validity Index** (CVI) as a representative indicator of quality: *0.78*

- At least **four of the five** experts *(4/5 = 0.8)* must classify the respective topic as relevant to reach the threshold

Research report
All topic descriptions
Available on ResearchGate

Exemplary topic descriptions based on the analysis and summarization of the respective statement

Topic: **Consistency**
Topic summarization:
This topic is about making your app feel familiar, safe, and easy to use. It includes using standard icons, common interaction patterns, and consistent visuals so users know what to expect. Avoid making people learn new ways to do simple things when familiar ones work just fine.

32 topics with 284 statements were evaluated as relevant for AR in CT.

RheinMain University of Applied Sciences

AGENDA

1. Introduction & Related Research
2. Methodology
3. Results
4. **Conclusion**

IMPLICATIONS

RheinMain University of Applied Sciences

- **Actualized dataset** of AR-specific design recommendations.
- Indication of relevant topics and respective statements for the CT domain.
- Provision of summarized and communicable topics based on the respective statements.

DISCUSSION & LIMITATIONS

RheinMain University of Applied Sciences

- The majority of newly identified statements result from one company.
- SBERT is a pre-trained model based on a general training dataset
- High complexity due to the large number of statements within the topics
- It remains unclear **whether using the recommendations actually improves** the application

OUTLOOK & FUTURE RESEARCH

RheinMain University of Applied Sciences

- Basis for extending our previous research on UX evaluation: Combined with our existing UXARcis measurement approach, follow-up research aims to:

  // examine the extent to which compliance or non-compliance with our AR design recommendation topics has a **systematic and predictable impact** on specific UX dimensions

  // to identify subsets of AR design recommendation topics that can be suggested to **systematically improve deficiencies** identified for specific UX dimensions

- **Preliminary classification** results are conducted *(accepted for publication @WEBIST 2025)*

- Further simplifying existing recommendations to **provide an easy-to-use list**

➔ ***More evidence-based system development with an early UX integration***

THANK YOU FOR YOUR ATTENTION!

Stefan Graser (MSc)

Doctoral Candidate & Research Associate

E-Mail: stefan.graser@hs-rm.de

ORCID: 0000-0002-5221-2959

Dr. Martin Schrepp

UX Expert & Researcher

SAP SE

E-Mail: martin.schrepp@sap.com

ORCID: 0000-0001-7855-2524

Prof. Dr. Stephan Böhm

Professor for Telecommunication and Mobile Media

E-Mail: stephan.boehm@hs-rm.de

ORCID: 0000-0003-3580-1038

Connect!

REFERENCES (1/5)

RheinMain University of Applied Sciences

1. V. Kraus, A. Boden, L. Oppermann, and R. Reiners, “Current Practices, Challenges, and Design Implications for Collaborative AR/VR Application Development,” in Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems, ser. CHI ’21, New York, NY, USA: Association for Computing Machinery, May 2021, pp. 1–15, ISBN: 978-1-4503-8096-6. DOI: 10.1145/3411764.3445335.
2. P. Naur and B. Randell, Software Engineering: Report of a conference sponsored by the NATO Science Committee, Garmisch, Germany, 7-11 Oct. 1968, Brussels, Scientific Affairs Division, NATO. 1969.
3. Brooks, “No silver bullet essence and accidents of softwareengineering,” Computer, vol. 20, no. 4, pp. 10–19, 1987. DOI:10.1109/MC.1987.1663532.
4. I. Sommerville, Software Engineering, 9th ed. New York, NY,USA: Addison-Wesley, 2010, ISBN: 9780137035151.
5. E. Hull, K. Jackson, and J. Dick, Requirements Engineering, 3rd ed. Berlin Heidelberg: Springer-Verlag, 2011, ISBN: 978-3-642-12550-0. DOI: 10.1007/978-3-642-12550-0.
6. C. Pacheco, I. Garcia, and M. Reyes, “Requirements elicitation techniques: A systematic literature review based on the maturity of the techniques,” IET Software, vol. 12, no. 4, pp. 365–378, Aug. 2018. DOI: 10.1049/iet-sen.2017.0144.
7. J. Nicolas Ros and A. Toval, “On the generation of requirements specifications from software engineering models: A systematic literature review,” Information and Software Technology, vol. 51, pp. 1291–1307, Sep. 2009. DOI: 10.1016/j.infsof.2009.04.001.
8. N. Condori-Fernandez et al., “A systematic mapping study on empirical evaluation of software requirements specifications techniques,” in 2009 3rd International Symposium on Empirical Software Engineering and Measurement, IEEE, 2009, pp. 502–505.
9. C. Pacheco and I. Garcia, “A systematic literature review of stakeholder identification methods in requirements elicitation,” Journal of Systems and Software, vol. 85, no. 9, pp. 2171– 2181, 2012, Selected papers from the 2011 Joint Working IEEE/IFIP Conference on Software Architecture (WICSA 2011), ISSN: 0164-1212. DOI: https : / / doi . org / 10 . 1016 / j .jss.2012.04.075.
10. N. Riegel and J. Doerr, “A systematic literature review of requirements prioritization criteria,” in Requirements Engineering Foundation for Software Quality, S. A. Fricker and K. Schneider, Eds., Cham: Springer International Publishing, 2015, pp. 300–317, ISBN: 978-3-319-16101-3.
11. A. Davis, O. Dieste, A. Hickey, N. Juristo, and A. M. Moreno, “Effectiveness of requirements elicitation techniques: Empirical results derived from a systematic review,” in 14th IEEE International Requirements Engineering Conference (RE’06), 2006, pp. 179–188. DOI: 10.1109/RE.2006.17. O. Dieste Tubio, M. Lopez, and F. Ramos, “Updating a systematic review about selection of software requirements elicitation techniques,” 11th Workshop on Requirements Engineering, WER 2008 - Proceedings, pp. 96–103, Jan. 2008.
12. R. Berntsson Svensson, M. Host, and B. Regnell, “Managing quality requirements: A systematic review,” Sep. 2010, pp. 261–268. DOI: 10.1109/SEAA.2010.55.
13. O. Dieste and N. Juristo, “Systematic review and aggregation of empirical studies on elicitation techniques,” IEEE Transactions on Software Engineering, vol. 37, no. 2, pp. 283–304, 2011. DOI: 10.1109/TSE.2010.33.
14. International Organization for Standardization 9241-210:2019, Ergonomics of human-system interaction — Part 210: Human centred design for interactive systems. ISO – International Organization for Standardization, 2019.

REFERENCES (2/5)

RheinMain University of Applied Sciences

15. J. L. Gabbard and J. Swan II, “Usability engineering for augmented reality: Employing user-based studies to inform design,” IEEE Transactions on Visualization and Computer 4, no. 3, pp. 513–525, 2008. DOI: 10.1109/TVCG.2008.24.
16. M. E. Santos et al., “Toward guidelines for designing handheld maugmented reality in learning support,” Dec. 2015.
17. V. Kraus, F. Jasche, S. M. Sasmannshausen, T. Ludwig, and A. Boden, “Research and practice recommendations for mixed reality design – different perspectives from the community,” in Proceedings of the 27th ACM Symposium on Virtual Reality Software and Technology, ser. VRST ’21, Osaka, Japan: Association for Computing Machinery, 2021, ISBN: 9781450390927. DOI: 10.1145/3489849.3489876.
18. J. Hebaj, V. Kraus, Y. Uzun, W. Prinz, and M. Jarke, “Towards design guidelines for ar training applications in controlled environments,” in GI VR/AR Workshop, Gesellschaft fur Informatik eV, 2021, pp. 10–18 420.
19. N. Ashtari, A. Bunt, J. McGrenere, M. Nebeling, and P. K. Chilana, “Creating augmented and virtual reality applications: Current practices, challenges, and opportunities,” in Proceedings of the 2020 CHI Conference on Human Factors´in Computing Systems, ser. CHI ’20, Honolulu, HI, USA: Association for Computing Machinery, 2020, pp. 1–13, ISBN: 9781450367080. DOI: 10.1145/3313831.3376722.
20. S. Graser, M. Schrepp, J. M. Kruger, and S. Bohm, “Development of an innovative ux measurement approach for augmented reality in corporate training,” [Unpublished manuscript, accepted for publication in the HCII 2025 – Late Breaking Papers Springer LNCS volumes of the Proceedings, 2025.
21. S. Bohm and B. Igler, “A tool-based approach for structuring feedback for user interface evaluations of mobile applications,” Aug. 2013, pp. 1–4. DOI: 10.13140/RG.2.1.4175.0163.Graphics, vol. 1.
22. K. K. Fu, M. C. Yang, and K. L. Wood, “Design principles: Literature review, analysis, and future directions,” Journal of Mechanical Design, vol. 138, no. 10, p. 101 103, Aug. 2016, ISSN: 1050-0472. DOI: 10.1115/1.4034105.
23. D. A. Norman, “Design principles for human-computer interfaces,” in Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, ser. CHI ’83, Boston, Massachusetts, USA: Association for Computing Machinery, 1983, pp. 1–10, ISBN: 0897911210. DOI: 10.1145/800045.801571.
24. J. Preece, H. Sharp, and Y. Rogers, Interaction Design: Beyond Human-Computer Interaction, 4th ed. Chichester, UK: Wiley, 2015, ISBN: 9781119020752.
25. J. Nielsen, “Finding usability problems through heuristic evaluation,” in Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, ser. CHI ’92, Monterey, California, USA: Association for Computing Machinery, 1992, pp. 373–380, ISBN: 0897915135. DOI: 10 . 1145 / 142750 .142834.
26. J. Beck and H. R. Ekbia, “The theory-practice gap as generative metaphor,” in Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems, ser. CHI ’18, Montreal QC, Canada: Association for Computing Machinery, 2018, pp. 1–11, ISBN: 9781450356206. DOI: 10 . 1145 / 3173574 .3174194.
27. D. J. Roedl and E. Stolterman, “Design research at chi and its applicability to design practice,” ser. CHI ’13, Paris, France: Association for Computing Machinery, 2013, pp. 1951–1954, ISBN: 9781450318990. DOI: 10.1145/2470654.2466257.

REFERENCES (3/5)

RheinMain University of Applied Sciences

28. S. S. Agati, R. D. Bauer, M. d. S. Hounsell, and A. S. Paterno, “Augmented reality for manual assembly in industry 4.0: Gathering guidelines,” in 2020 22nd Symposium on Virtual and Augmented Reality (SVR), IEEE, 2020, pp. 179–188. DOI:´10.1109/SVR51698.2020.00039.
29. R. Haegle, B. Breitkopf, L. Eiler, and K. Kloepfer, “Developing Design Guidelines For Augmented Reality Applications As Operating Assistance For Manufacturing Machines,” eng, pp. 192–203, 2024, Book Title: Proceedings of the Conference on Production Systems and Logistics: CPSL 2024 Publisher: Hannover : publish-Ing. DOI: 10.15488/17712.
30. N. F. S. Jeffri and D. R. A. Rambli, “Guidelines for the interface design of ar systems for manual assembly,” in Proceedings of the 2020 4th International Conference on Virtual and Augmented Reality Simulations, ser. ICVARS ’20, Sydney, NSW, Australia: Association for Computing Machinery, 2020, pp. 70–77, ISBN: 9781450376945. DOI: 10 . 1145 / 3385378 .3385389.
31. N. Chen et al., “Using online videos as the basis for developing design guidelines: A case study of ar-based assembly instructions,” Proc. ACM Hum.-Comput. Interact., vol. 7, no. ISS, Nov. 2023. DOI: 10.1145/3626464.
32. P. Milgram, H. Takemura, A. Utsumi, and F. Kishino, “Augmented reality: A class of displays on the reality-virtuality continuum,” en, in Proceedings of SPIE - The International Society for Optical Engineering, ser. 2351, 1994, pp. 282–292. DOI: 10.1117/12.197321.
33. Apple Inc., “Augmented reality human interface guidelines,” Apple Developer Documentation, 2025, [Online]. Available: https://developer.apple.com/design/human-interface-guidelines/augmented-reality#app-top (visited on 04/23/2025).
34. Google Developers, “Augmented reality design guidelines,”ARCore UX Design Guidelines, Oct. 2024, [Online]. Available: https://developers.google.com/ar/design (visited on 04/23/2025).
35. Microsoft Corporation, Mixed reality dokumentation, https://learn.microsoft.com/de-de/windows/mixed-reality/, 2025.
36. “Best practices,” Magic Leap Developer Documentation, Jan. 2025, [Online]. Available: https://developer- docs.magicleap. cloud/docs/category/best-practices/ (visited on 04/23/2025).
37. Meta Platforms, Inc., “Technical guidelines,” Meta Spark Learn, 2025, [Online]. Available: https : / / spark . meta . com / learn / articles / fundamentals / technical - guidelines (visited on 04/23/2025).
38. S. Behnam and R. Budiu, “The usability of augmented reality,” Nielsen Norman Group, Nov. 2022, [Online]. Available: https://www. nngroup.com/articles/ar-ux-guidelines/ (visited on 04/23/2025).
39. Z.Wang et al., “A comprehensive review of augmented realitybased instruction in manual assembly, training and repair,” Robotics and Computer-Integrated Manufacturing, vol. 78, p. 102 407, Dec. 2022, ISSN: 0736-5845. DOI: 10 . 1016 / j.rcim.2022.102407.
40. Y. Li, D. McLean, Z. Bandar, J. O’Shea, and K. Crockett, “Sentence similarity based on semantic nets and corpus statistics,” IEEE Transactions on Knowledge and Data Engineering, vol. 18, no. 8, pp. 1138–1150, 2006. DOI: 10.1109/TKDE. 2006.130.
41. H. P. Luhn, “A statistical approach to mechanized encoding and searching of literary information,” IBM Journal of research and development, vol. 1, no. 4, pp. 309–317, 1957.
42. T. Mikolov, I. Sutskever, K. Chen, G. S. Corrado, and J. Dean, “Distributed representations of words and phrases and their compositionality,” in Advances in Neural Information Processing Systems, C. Burges, L. Bottou, M. Welling, Z. Ghahramani, and K. Weinberger, Eds., vol. 26, Curran Associates, Inc., 2013.

REFERENCES (4/5)

RheinMain University of Applied Sciences

43. Q. Le and T. Mikolov, “Distributed representations of sentences and documents,” in Proceedings of the 31st International Conference on Machine Learning, E. P. Xing and T. Jebara, Eds., ser. Proceedings of Machine Learning Research, vol. 32, Bejing, China: PMLR, 22–24 Jun 2014, pp. 1188– 1196.
44. N. Reimers and I. Gurevych, “Sentence-bert: Sentence embeddings using siamese bert-networks,” in Proceedings of the 2019 Conference on Empirical Methods in Natural Language Processing, Association for Computational Linguistics, Nov. 2019.
45. J. Devlin, M.-W. Chang, K. Lee, and K. Toutanova, “BERT: Pre-training of deep bidirectional transformers for language understanding,” J. Burstein, C. Doran, and T. Solorio, Eds., pp. 4171–4186, 2019. DOI: 10.18653/v1/N19-1423.
46. A. Vaswani et al., “Attention is all you need,” in Advances in Neural Information Processing Systems, I. Guyon et al., Eds., vol. 30, Curran Associates, Inc., 2017.
47. K. Wang, Y. Zeng, F. Meng, Feiyu, and L. Yang, “Comparison between calculation methods for semantic text similarity based on siamese networks,” in 2021 4th International Conference on Data Science and Information Technology, 2021, pp. 389–395.
48. S. Graser and S. Bohm, “Quantifying user experience through self-reporting questionnaires: A systematic analysis of sentence similarity between the items of the measurement approaches,” in Lecture Notes in Computer Science, LNCS, volume 14014, 2023.
49. S. Graser, S. Bohm, and M. Schrepp, “Using chatgpt-4 for the identification of common ux factors within a pool of measurement items from established ux questionnaires,” in CENTRIC 2023, The Sixteenth International Conference on Advances in Human-oriented and Personalized Mechanisms, Technologies, and Services, 2023.
50. S. Graser, M. Schrepp, and S. Bohm, “Identifying Semantic Similarity for UX Items from Established Questionnaires using ChatGPT-4,” International Journal on Advances in Systems and Measurements, vol. 17, no. 12, pp. 67–82, 2024.#
51. S. Graser, Sts_sbert_centric2025: Semantic similarity-based clustering and classification of ar guidelines, https://github.com/stefangraser/STS_SBERT_Centric2025, Accessed: April 24, 2025, 2025.
52. A. Petukhova, J. P. Matos-Carvalho, and N. Fachada, “Text clustering with large language model embeddings,” International Journal of Cognitive Computing in Engineering, vol. 6, pp. 100–108, 2025.
53. R. H. Pierson and E. A. Fay, “Guidelines for interlaboratory testing programs,” Analytical Chemistry, vol. 31, no. 12, 25A–49A, 1959. DOI: 10.1021/ac60156a708. eprint: https://doi.org/10.1021/ac60156a708.
54. J. Nielsen and T. K. Landauer, “A mathematical model of the finding of usability problems,” in Proceedings of the INTERACT ’93 and CHI ’93 Conference on Human Factors in Computing Systems, ser. CHI ’93, Amsterdam, The Netherlands: Association for Computing Machinery, 1993, pp. 206–213, ISBN: 0897915755. DOI: 10.1145/169059.169166.
55. S. Graser, M. Schrepp, J. Kollmorgen, M. J. Escalona, and S. Bohm, Classification of ar design recommendations on ux dimensions: Preliminary study results: Research report data, Jun. 2025. DOI: 10.13140/RG.2.2.28124.71047.

REFERENCES (5/5)

RheinMain University of Applied Sciences

56. Q. Le and TD. F. Polit, C. T. Beck, and S. V. Owen, “Is the cvi an acceptable indicator of content validity? appraisal and recommendations,” Research in Nursing & Health, vol. 30, no. 4, pp. 459–467, 2007. DOI: https://doi.org/10.1002/nur.20199.eprint: https://onlinelibrary.wiley.com/doi/pdf/10.1002/nur.20199.

57. J. Nielsen and R. Molich, “Heuristic evaluation of user interfaces,”in Proceedings of the SIGCHI conference on Human factors in computing systems, 1990, pp. 249–256. V. Roto, H. Rantavuo, and K. Vaananen-Vainio-Mattila, “Evaluating user experience of early product concepts,” in Proceedings of Designing Pleasurable Products and Interfaces 2009, DPPI’09, 2009.

58. A. P. O. S. Vermeeren et al., “User experience evaluation methods: Current state and development needs,” in Proceedings of the 6th Nordic Conference on Human-Computer Interaction: Extending Boundaries, ser. NordiCHI ’10, New York, NY, USA: Association for Computing Machinery, Oct. 2010, pp. 521–530, ISBN: 978-1-60558-934-3. DOI: 10.1145/1868914.1868973.

59. A. Lecaros, F. Paz, and A. Moquillaza, “Challenges and opportunities on the application of heuristic evaluations: A systematic literature review,” in Design, User Experience, and Usability: UX Research and Design, M. M. Soares, E. Rosenzweig, and A. Marcus, Eds., Cham: Springer International, Publishing, 2021, pp. 242–261, ISBN: 978-3-030-78221-4.

60. M. Hassenzahl, “The thing and i: Understanding the relationship between user and product,” in Funology: From Usability to Enjoyment, M. A. Blythe, K. Overbeeke, A. F. Monk, and P. C. Wright, Eds. Dordrecht: Springer Netherlands, 2004, pp. 31–42, ISBN: 978-1-4020-2967-7. DOI: 10.1007/1-4020-2967-5_4.

61. I. Pettersson, F. Lachner, A.-K. Frison, A. Riener, and A. Butz, “A Bermuda Triangle? A Review of Method Application and Triangulation in User Experience Evaluation,” in Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems, ser. CHI ’18, Montreal QC, Canada: Association for Computing Machinery, 2018, pp. 1–16, ISBN: 9781450356206. DOI: 10.1145/3173574.3174035.