MOBILE AUGMENTED REALITY: DESIGN PRINCIPLES FOR THE USE IN EDUCATIONAL SETTINGS

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Overview

1. Background and Goal
   Basic Assumptions | Research Gap and Goal

2. Theoretical Baseline
   TPACK | MAR in Education

3. Literature Review
   Method | Results

4. Further Work and Discussion
   MARLS | Closing the Gap | ...
Background and Goal | Basic Assumptions

**Why Focus on MAR?**

1) Augmented Reality may improve learning settings and make learning more effective (Bacca et al., 2014; Radu, 2012)

2) MAR is cost-efficient because mobile devices are widely available (Akçayır and Akçayır, 2017)

**Further Assumptions**

3) To use MAR and design effective MARLS in classrooms is challenging and teachers often lack the necessary media-didactical skills (Bucher et al., 2020; Cuendet et al., 2013)

4) Isolated knowledge about a technology and isolated knowledge about pedagogy are not sufficient to effectively use new technologies in classrooms (Mishra and Koehler, 2006)
Background and Goal | Research Gap and Goal

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**Research Gap**

- Shortage of principles illustrating how to effectively use MAR applications to design MARLS (Kerr and Lawson, 2020; Kourouthanassis et al., 2015)

**Theoretical Baseline**

- Review on MAR in education
  - TPACK Model (Mishra and Koehler, 2006)

**Literature Review**

- Review on MARLS design and MAR application

**Main Goal**

- Identification of design principles for MARLS

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AR: Augmented Reality  
MAR: Mobile Augmented Reality  
MARLS: MAR Learning Setting
## Theoretical Baseline | MAR in education

### Seven metastudies on MAR in education

Only 2015-2020 to account for considerable technical developments (Cuendet et al., 2013)

- Positive learning effects
- Increased motivation and engagement
- Change the perspective on learning objects
- New ways to interact with materials, teachers and other learner

- Technological difficulties
  - High complexity for teachers and learners

- Research and practical interest for MAR in education is growing
  - “Novelty effect”

<table>
<thead>
<tr>
<th>Metastudy</th>
<th>No of Analyzed Studies (346)</th>
<th>Years of Analyzed Studies</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Chen et al., 2017)</td>
<td>55</td>
<td>2011 – 2016</td>
</tr>
<tr>
<td>(Garzón et al., 2019)</td>
<td>61</td>
<td>2012 – 2018</td>
</tr>
<tr>
<td>(Quintero et al., 2019)</td>
<td>50</td>
<td>2008 – 2018</td>
</tr>
<tr>
<td>(Sommerauer and Müller, 2018)</td>
<td>36</td>
<td>2010 – 2017</td>
</tr>
<tr>
<td>(Yuliono et al., 2018)</td>
<td>18</td>
<td>2009 – 2018</td>
</tr>
</tbody>
</table>
Isolated knowledge about a technology and isolated knowledge about pedagogy are not sufficient to effectively use new technologies in classrooms (Mishra and Koehler, 2006)

- Teachers have pedagogical knowledge
- Teachers have content knowledge
- Combinations of content knowledge with technological and pedagogical knowledge varies with the content

➢ Focus on technological pedagogical knowledge to identify general MARLS design principles

TPACK to identify MARLS design principles (adapted from: Mishra and Koehler, 2006, p. 1025)
### Literature Review | Method

<table>
<thead>
<tr>
<th>Database</th>
<th>BASE, ERIC, Science Citation Index, Science Direct, and Scopus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Query</td>
<td>(“design principle” OR “design framework” OR “usability principle”) AND (educat* OR learn* OR school OR teach*) AND (“augment* reality”)</td>
</tr>
<tr>
<td>First search</td>
<td>155 found in title or abstract</td>
</tr>
<tr>
<td>Inclusion</td>
<td>77 read no duplicates, 2010-2020, online available, scientific journal</td>
</tr>
<tr>
<td>Analysis</td>
<td>12 analyzed design principles or frameworks for the construction or application of MAR for educational purposes</td>
</tr>
</tbody>
</table>

→ Few results because of research gap?
<table>
<thead>
<tr>
<th>Study</th>
<th>Theoretical Foundation</th>
<th>Design Principles</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Altmeyer et al., 2020)</td>
<td>Spatial contiguity principle, Cognitive load theory, Cognitive theory of multimedia learning</td>
<td>1 Avoid split-attention effect, 2 Use common technology and context</td>
</tr>
<tr>
<td>(Bucher et al., 2020)</td>
<td>Learning technology by design, Action-oriented didactics, Basic of media pedagogy, Basics of HCI</td>
<td>1 Learning activities, 2 Teaching activities, 3 Interdisciplinarity</td>
</tr>
<tr>
<td>(Cuendet et al., 2013)</td>
<td>Usability of HCI settings, Classroom orchestration, Design whole learning settings</td>
<td>1 Integration, 2 Empowerment, 3 Awareness, 4 Flexibility, 5 Minimalism</td>
</tr>
<tr>
<td>(Dunleavy, 2014)</td>
<td>Intrinsic motivation</td>
<td>1 Enable than challenge, 2 Gamified story, 3 See the unseen</td>
</tr>
<tr>
<td>(Kerr and Lawson, 2020)</td>
<td>Digital storytelling, Physicality of learning object, Scaffolding, Informal learning</td>
<td>1 Experiential theme/s, 2 Unique narrative, 3 Multisensory design, 4 Design for gaps, 5 Collaboration</td>
</tr>
<tr>
<td>(Ko et al., 2013)</td>
<td>Usability of mobile applications</td>
<td>1 User-information, 2 User-cognitive, 3 User-support, 4 User-interaction, 5 User-usage</td>
</tr>
<tr>
<td>(Kourouthanassis et al., 2015)</td>
<td>Usability of mobile applications</td>
<td>1 Context, 2 To-the-task content, 3 Transparency, 4 Feedback on infrastructure, 5 Memory</td>
</tr>
<tr>
<td>(Messuti et al., 2015)</td>
<td>Basic learning theories, Usability of mobile applications</td>
<td>1 Basis in learning theories, 2 Simple interface and usability, 3 Blend the environment</td>
</tr>
<tr>
<td>(Sommerauer and Müller, 2018)</td>
<td>Lens of theory, General learning theories</td>
<td>1 Mobile learning, 2 Game based learning, 3 Experiential learning, 4 Situated learning</td>
</tr>
<tr>
<td>(Stefan and Moldoveanu, 2013)</td>
<td>Game based learning</td>
<td>1 Playability, 2 Emotional appeal, 3 Player's contribution, 4 Challenge, 5 Curiosity, 6 Control, 7 Fantasy, 8 Motivation, 9 Iteration, 10 Scaffolding</td>
</tr>
<tr>
<td>(Tuli and Mantri, 2020)</td>
<td>Usability of mobile applications, AR design principles</td>
<td>1 Cognition, 2 Orientation, 3 Design, 4 Support</td>
</tr>
<tr>
<td>(Zhao, 2018)</td>
<td>Interactive interface design method, Multiple analysis</td>
<td>1 User centeredness, 2 Consistency, 3 Rationality and clarity, 4 Diversity, 5 Interactivity</td>
</tr>
</tbody>
</table>
Literature Review | Results

54 Design Principles

- Named by 3 or more studies
- Usability (techn.)
- User/learner centeredness (pedag.)
- Cognitive (over)load

Clusters of remaining principles

- Clusters of remaining principles
- Basic learning theories
- Conscious application of MAR

19 remaining Principles

- Learning activities
- Teaching activities
- Interdisciplinarity

(Bucher et al., 2020)

- Integration (in curriculum)
- Empowerment (of teachers)
- Awareness (for MAR advantages)

(Cuendet et al., 2013)

- Enable than challenge
- See the unseen (thanks to MAR)

(Dunleavy, 2014)

- Multisensory design
- Design for gaps
- Collaboration

(Kerr and Lawson, 2020)

- Basis in learning theories
- Blend the environment

(Messuti et al., 2015)

- Mobile learning
- Experiential learning
- Situated learning

(Sommerauer and Müller, 2018)

- Challenge
- Iteration
- Scaffolding

(Stefan and Moldoveanu, 2013)
## Literature Review | Results

<table>
<thead>
<tr>
<th>MARLS Design Principles</th>
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<tbody>
<tr>
<td><strong>Usability (techn.)</strong></td>
</tr>
<tr>
<td>– easy and appealing to use for teachers and students (Cuendet et al., 2013)</td>
</tr>
<tr>
<td>– interface containing only relevant information and functions (Ko et al., 2013)</td>
</tr>
<tr>
<td><strong>User/learner centeredness (pedag.)</strong></td>
</tr>
<tr>
<td>– focus on the needs and requirements of the targeted learners (Stefan and Moldoveanu, 2013)</td>
</tr>
<tr>
<td>– easy classroom management and efficient use of the scarce learning time (Cuendet et al., 2013)</td>
</tr>
<tr>
<td>– motivational design and a context relevant to the learners (Dunleavy, 2014; Kerr and Lawson, 2020)</td>
</tr>
<tr>
<td><strong>Basic learning theories</strong></td>
</tr>
<tr>
<td>– classical learning theories still apply for MARLS (Messuti et al., 2015)</td>
</tr>
<tr>
<td>– create motivational and learner-centered MARLS (Bucher et al., 2020)</td>
</tr>
<tr>
<td><strong>Conscious application of MAR</strong></td>
</tr>
<tr>
<td>– organize and scaffold the activities to use the learning time effectively (Stefan and Moldoveanu, 2013)</td>
</tr>
<tr>
<td>– restrict MAR use to the activities where it supports the learning process effectively (Tuli and Mantri, 2020)</td>
</tr>
<tr>
<td><strong>Cognitive (over)load</strong></td>
</tr>
<tr>
<td>– special attention to the cognitive load of students (Garzón et al., 2019) and teachers (Cuendet et al., 2013)</td>
</tr>
</tbody>
</table>

→ Design for students AND teachers
<table>
<thead>
<tr>
<th>MAR- Parcours for High-School-Students</th>
<th>Refinement of DPs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Educational Design Research (EDR)</td>
<td>Institutional Requirements</td>
</tr>
</tbody>
</table>
Literature (1/2)


Literature (2/2)


