ETH
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RESEARCH GROUP FOR
Distributed Systems

Digitally Augmenting Traditional Play Environments

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Thesis

Traditional play environments can benefit from the merging of the virtual and the real world enabled by pervasive computing technologies.

However, to digitally augment such environments, many aspects must be considered and many technical challenges must be successfully overcome.

Challenges (Examples)

- Integration of technology (e.g., small play objects)
- It’s about fun: reliability, real-time response, etc.
- High dynamics of play environments
- Users do not have technical knowledge
- Special user group: children

Definitions

- Digitally Augmented Traditional Play Environment:
  a physical-traditional play environment that is
  digitally augmented using pervasive computing technologies
  in order to enhance the players' experience
  by providing them with novel virtual elements and/or services.

- Digital Augmentation:
  the process of
  integrating pervasive computing technologies into real-world objects
  to equip them with sensing, computing, storing and/or communication capabilities.

Contributions

Theoretical Background

Digital Augmentation

Two Exemplary Prototypes / Use Cases

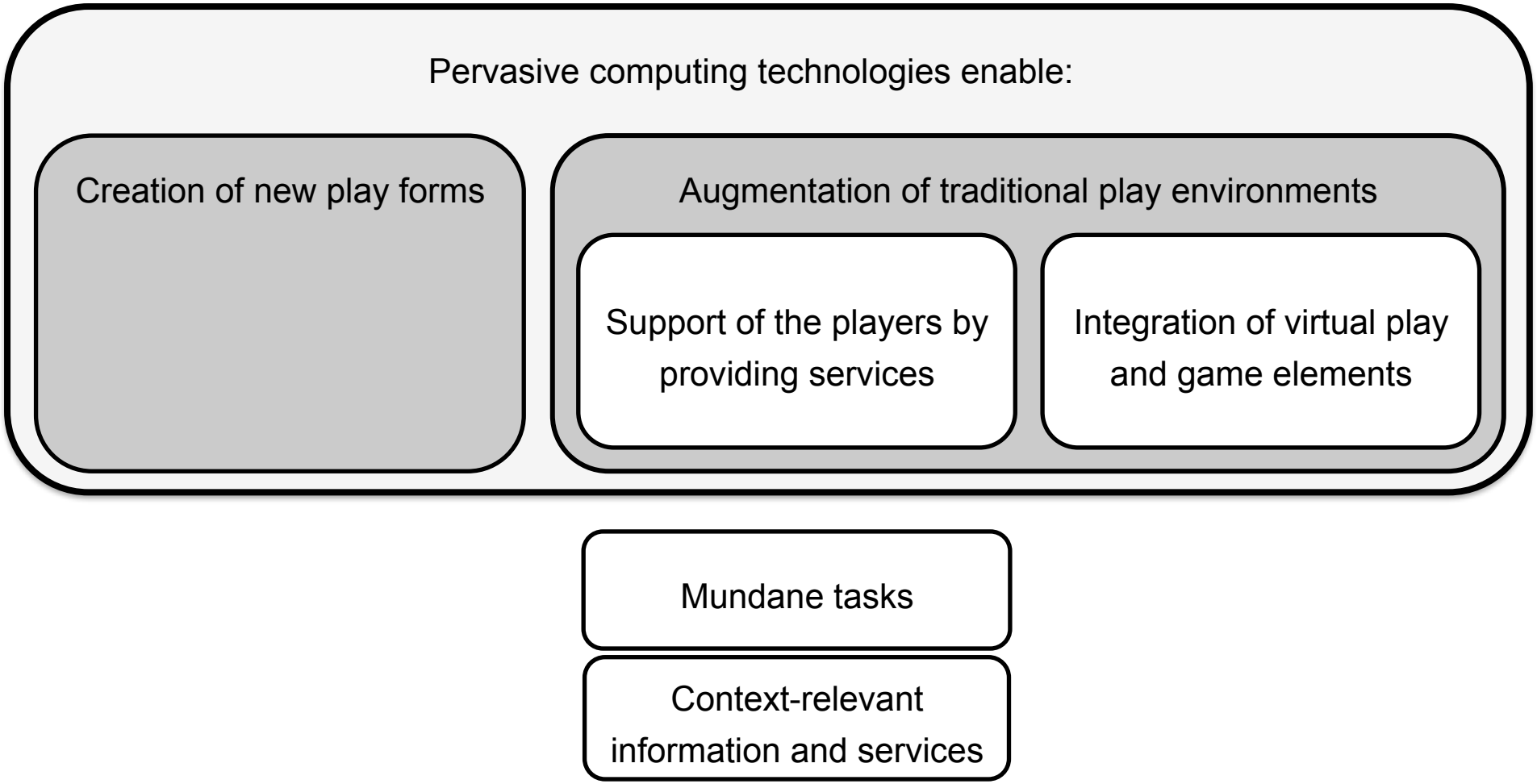
Warhammer 41K

The Augmented Knight's Castle

User Study of the AKC

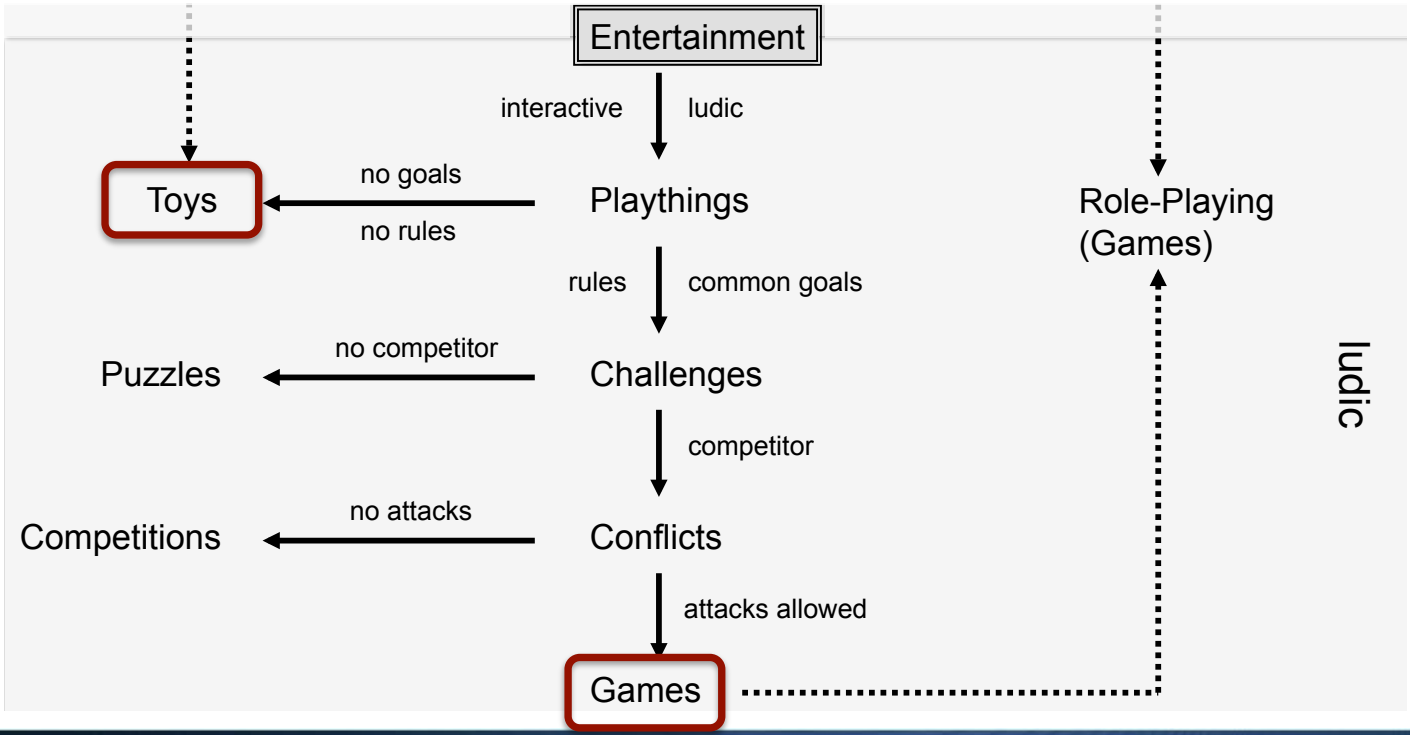
MOTIVATION AND BACKGROUND

Motivation


Pervasive computing technologies enable:
Creation of new play forms
Augmentation of traditional play environments
Support of the players by providing services
Integration of virtual play and game elements
Mundane tasks
Context-relevant information and services

Extended[1] Taxonomy of Entertainment

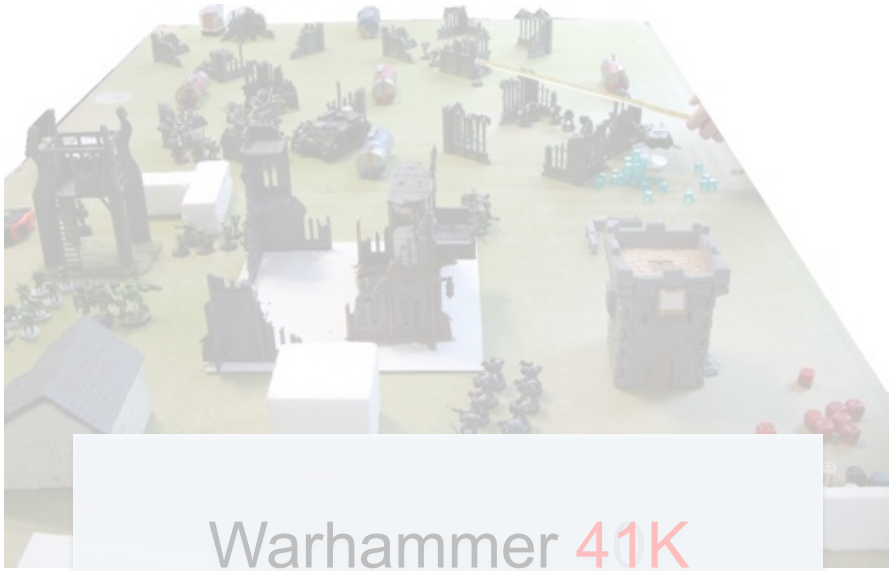
"Play: activities engaged for enjoyment"[2]



1: Based on Crawford. Chris Crawford on Game Design. New Riders Publ., 2003

2: Soanes & Hawker. Compact Oxford English Dictionary of Current English. Oxford University Press, 3rd edition, 2005.

Two Forms of Augmented Play Environments



Warhammer 41K

Knight's Castle (KC)

Augmented Knight's Castle (AKC)

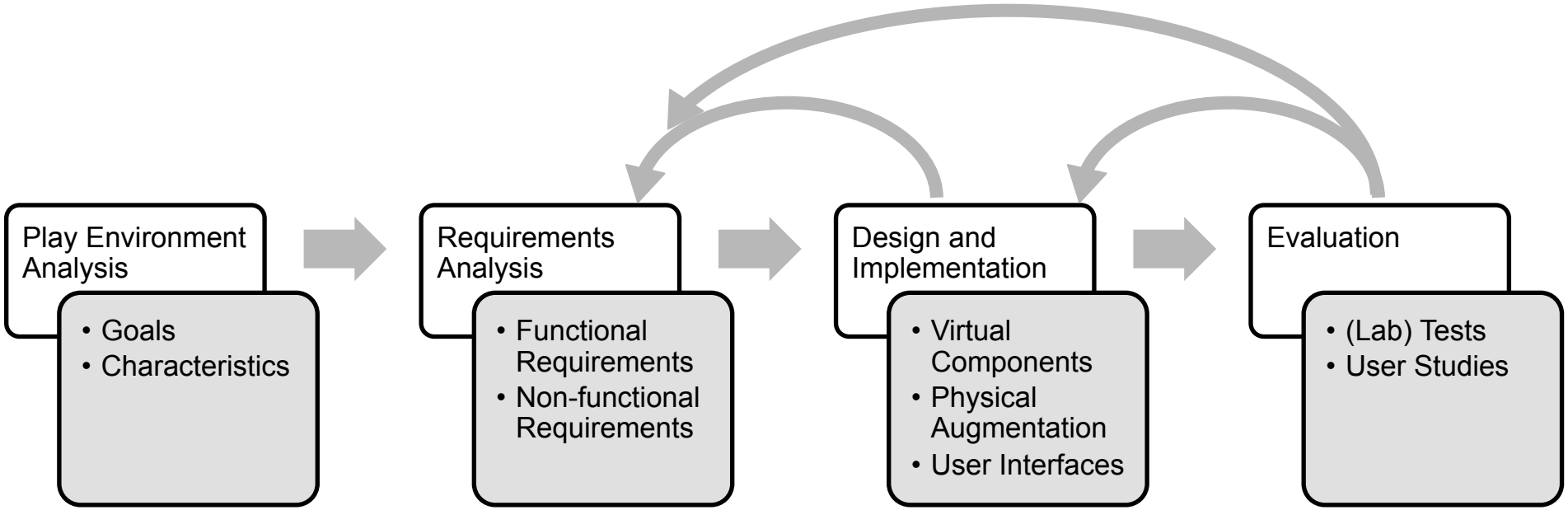
DIGITAL AUGMENTATION: PROCESS AND DESIGN GUIDELINES

Problem

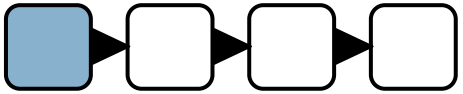
- How can we digitally augment a play environment
  to support players and create more immersive environments without compromising its tangible and social benefits?

- What parts of the play environment should be digitally augmented?
- How can these parts be digitally augmented?
- What (technical) aspects must be considered?

Process of Digital Augmentation



Play Environment Analysis

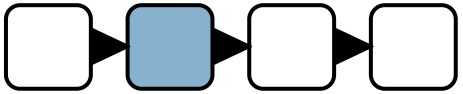


- Characteristics (examples)
  - Target user group
    - Primary users
    - Secondary users (spectators, parents, content provides, etc.)
  - Boundaries
    - Space
    - Objects
    - Players
    - Time
  - Rules, patterns

1: Huizinga. Homo Ludens. Beacon Press, June 1971.

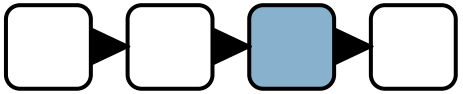
- Goals of digital augmentation
  - E.g., “relieve players of manual score-keeping”

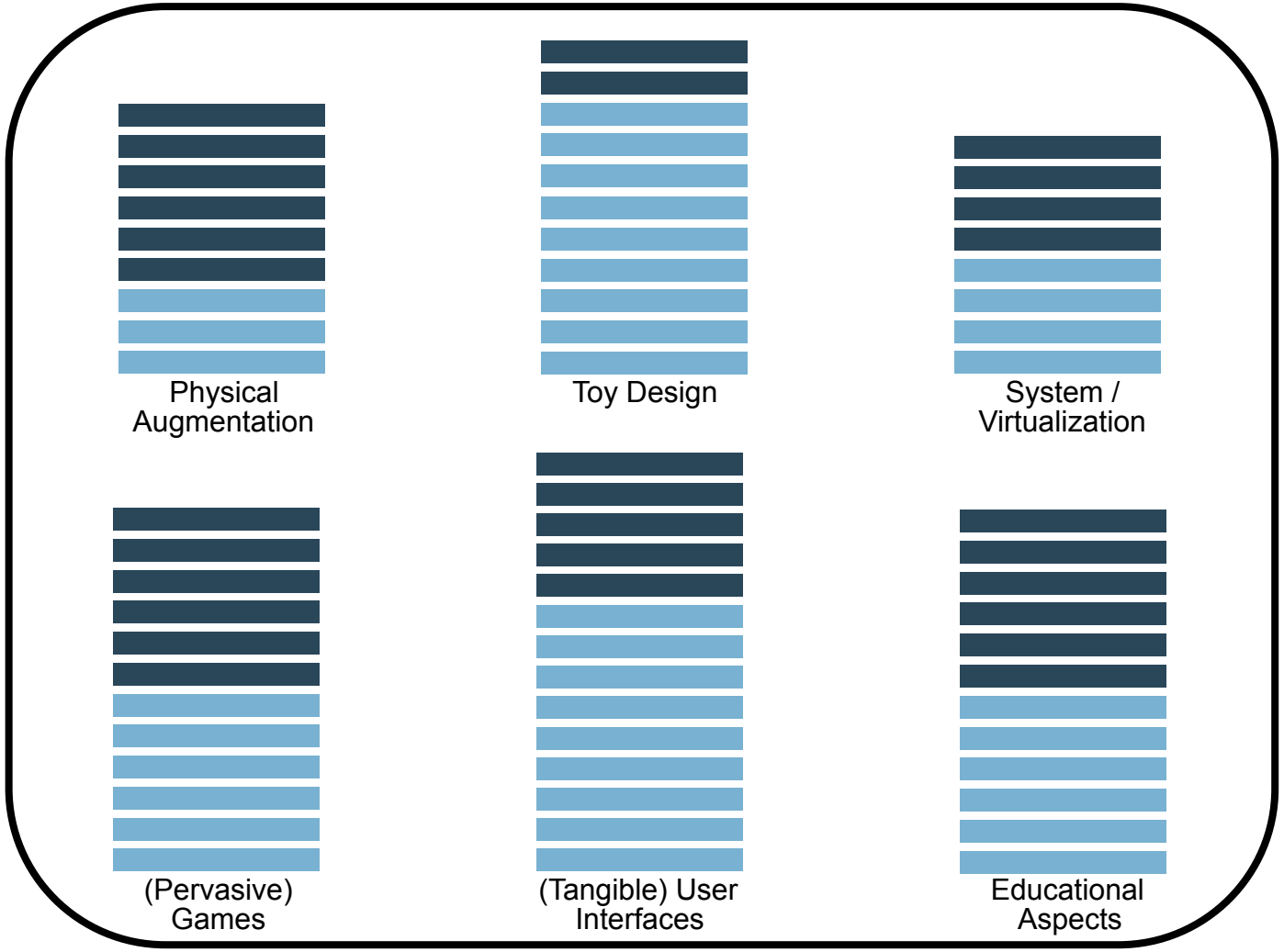
Requirements Analysis



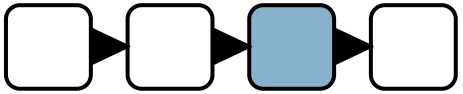
- Goal: “relieve the players of manual score-keeping”
- Functional requirement:
  “introduction of a virtual scorekeeper”
  - Provide means to retrieve current score
  - Catch game states that result in score changes
- Non-functional requirements (examples)
  - Reliability
  - Performance
  - Invisibility and unobtrusiveness

Design and Implementation





Design Guidelines (Examples)



- The play set should still be playable (in the “traditional” way); even if the technology is switched off or malfunctioning.
- Secondary user interfaces should be minimized.
- Strive for in situ interaction / situated action:
  interaction (e.g., configuration) happens right in the play.

Difficulties of Evaluating APEs

- Resource-intensive
- Evaluation in the field
- Evaluation of the complete system
- No evaluation standards
- Data gathering
- Technical issues

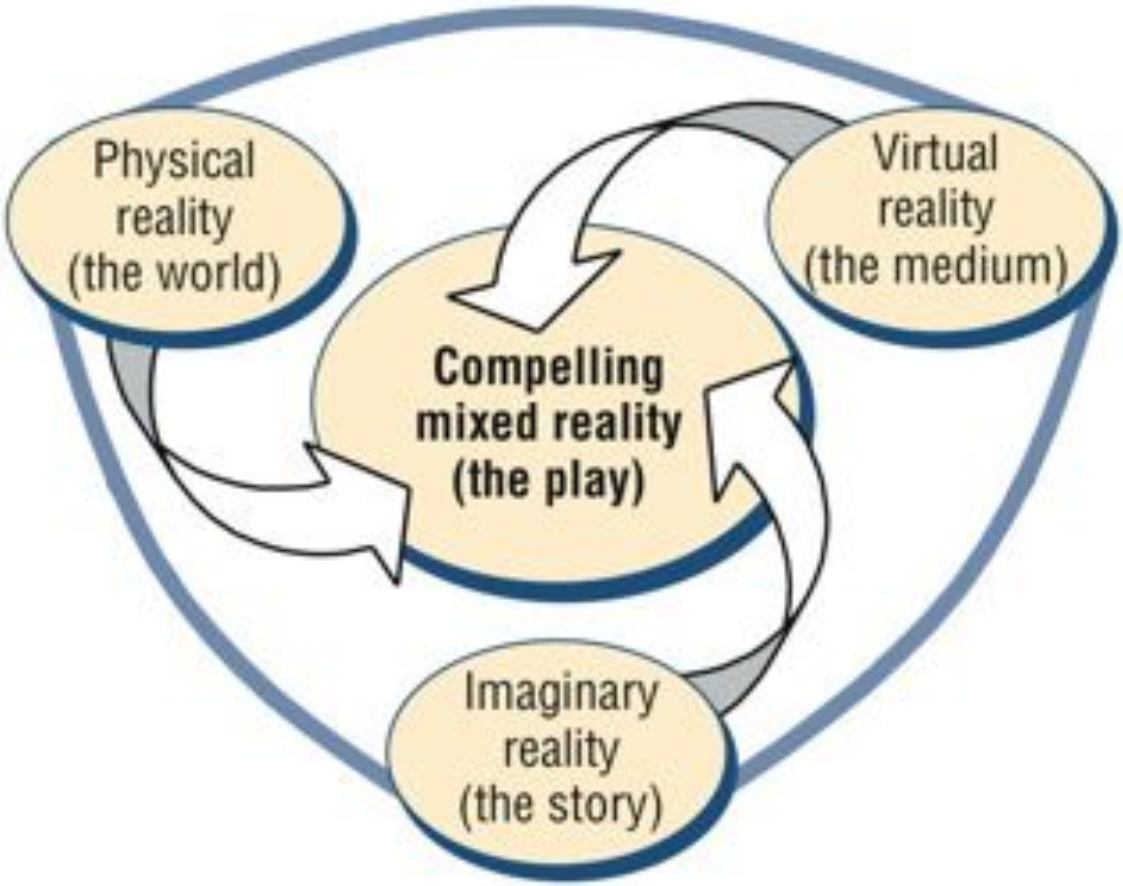
- Children as users
- It’s about fun

USE CASE:
THE AUGMENTED KNIGHT'S CASTLE

Characteristics (Examples)

- Number of players: unlimited. During a play session, players may join or leave.
- The play field is not spatially restricted and subject to constant changes. There are no discrete fields.
- The play set consists of many play objects. During a play session, new (semantically foreign) objects might be added.

Model of Compelling Mixed Reality[1]



1: Stapleton et al. Applying mixed reality to entertainment. Computer, 35(12):122–124, 2002.

Functional Requirements

Goal: enhance children's play experience and provide educational content in a playful way

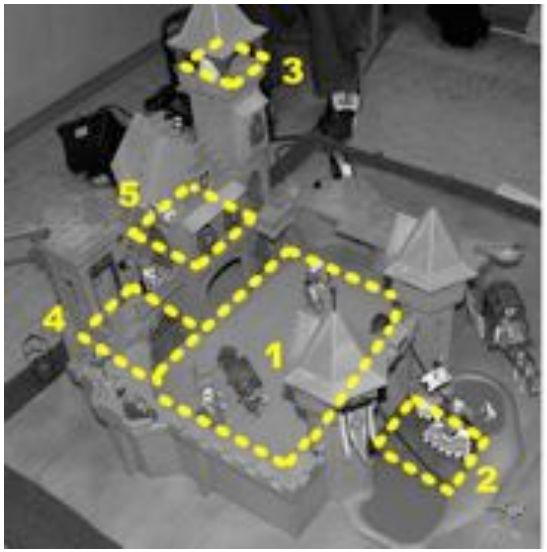
- Integration of novel (multimedia) effects FR1
- Integration of educational content for playful learning FR2
- Provision of means to configure the environment
- Integration of devices to enable new interaction forms

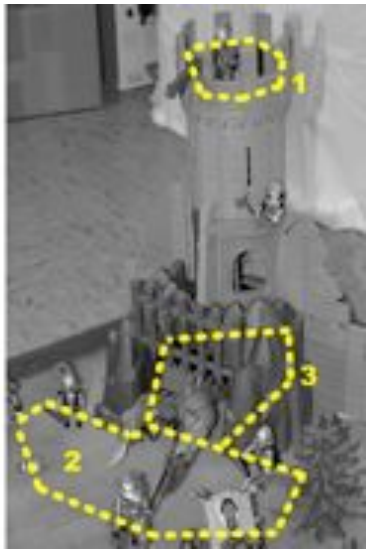
FR1 FR2

Identifying and Locating Objects

- Requirements:
  - Unambiguous identification ← Unique ID
  - Unobtrusive detection ← Small footprint of tags
  - Reliable and quasi-real-time ← Fast tag detection
  - Maintenance-free ← Low maintenance

RFID Technology



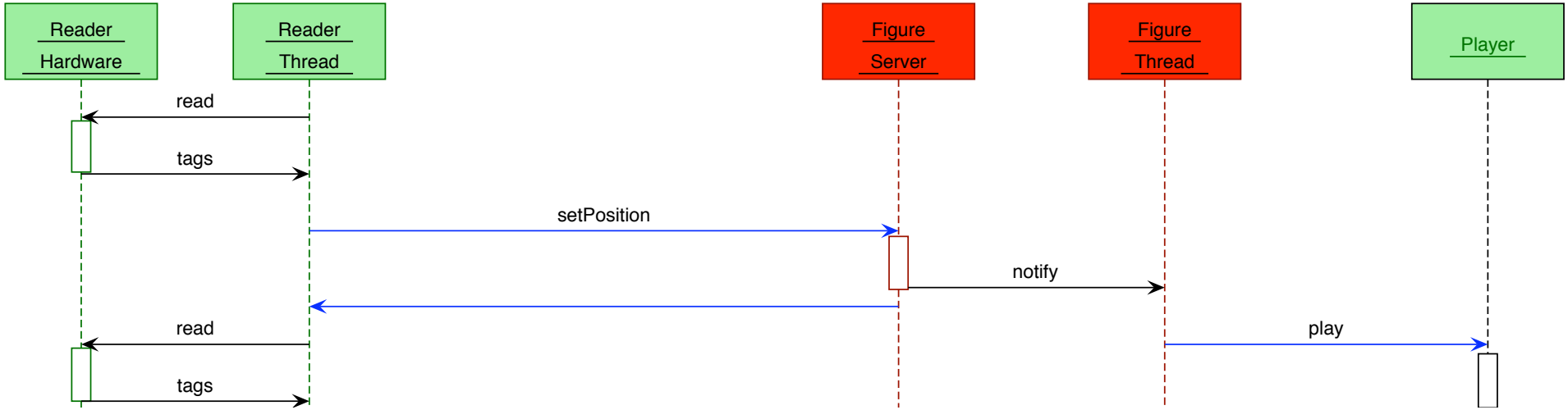



ROAR

FR1 FR2

Background System

- Idea: all information stored "in" the figures
- Each location operates independently
- Web services for flexibility



FR1 FR2

Additional Effects

- Light and smoke effects
- Also configurable

FR1 FR2

Integrating and Providing Educational Content

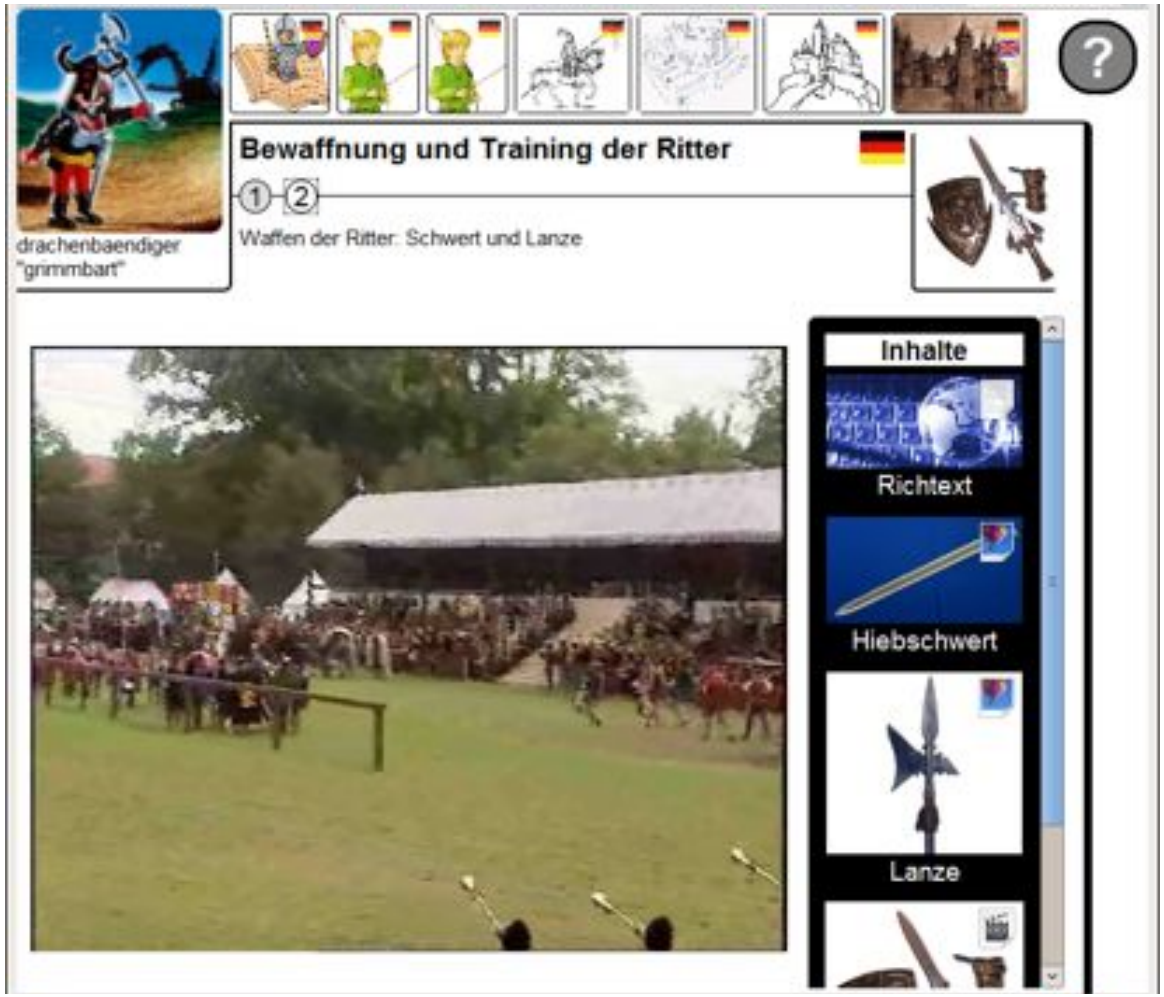
- Children:
  - Facts and stories about the Middle Ages in several languages
  - Directly (i.e., talking figures)
  - Indirectly (i.e., using a mediator device)

FR1 FR2

"Castle Tours"

FR1 FR2

"Magic Mirror" and "Magic Loupe"



FR1 FR2

Integrating and Providing Educational Content

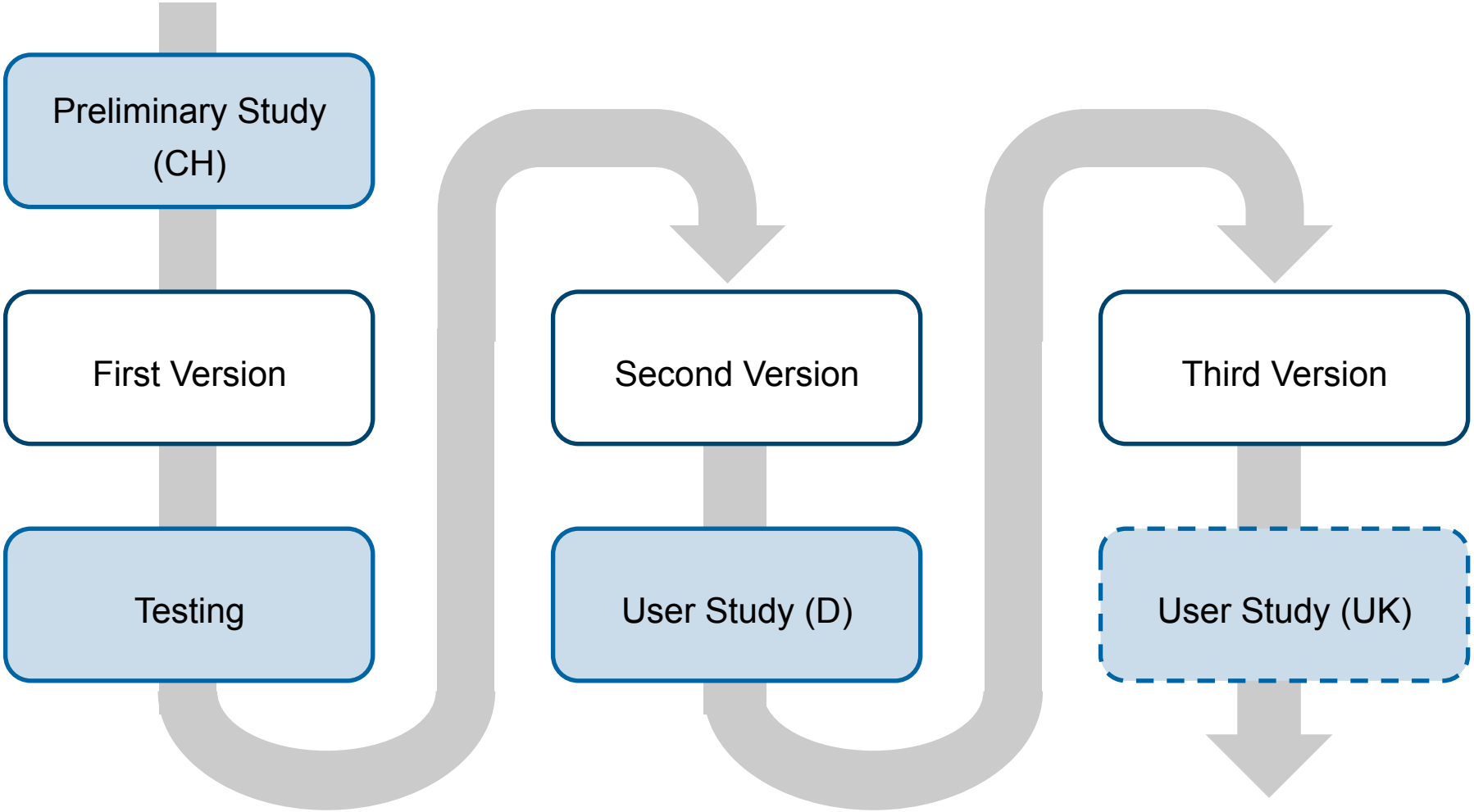
- Children: play learning modules
  - Facts and stories about the Middle Ages in several languages
  - Directly (i.e., talking figures)
  - Indirectly (i.e., using a mediator device)
- Parents / educators: modify and pre-select modules
  - Web-based user interface
  - Review individual interaction / learning histories
- Developers: create and modify modules
  - Content management system

Design Guidelines

- Invisibility and unobtrusiveness
- The technology must be safe (e.g., no electricity, sharp edges or poisonous materials).

- Support multiple simultaneous interactions.
- System feedback should always be immediate.

Iterative Development of the AKC



Three Major Iterations of the AKC

Initial Version	Second Version	Third Version
Slow response time	Quasi-real-time response	
Eight active zones: one RFID reader, one multiplexer and eight antennas	Nine active zones: nine readers, three multiplexers and 23 antennas	
Technology is loosely placed under a table		Everything is secured in place (enables easy transportation)
Storage: XML files	Storage: Database	
All action rules are hardcoded		Users can create and configure action rules
Integration of additional devices hardcoded		Web-service-based infrastructure for flexible integration of devices
Centralized play set with one computer		Distributed play set with three autonomous elements connected via WiFi
Audio feedback only		Audio feedback plus light and smoke effects






USER STUDY OF THE AUGMENTED KNIGHT'S CASTLE

Goals

- To test the success of the digital augmentation, mainly in terms of robustness and usability.
- To compare the augmented with the non-augmented play set in terms of children's perceptions of fun.
- To explore the effects of the augmented play set on interactive play and storytelling.
- To explore the value of an augmented play set for conveying educational content.

Two Play Sets

Method

- Each play set in a separate room
- Free play
- KC or AKC: 35-40min
- AKC/KC or KC/AKC: 20min each

Participants

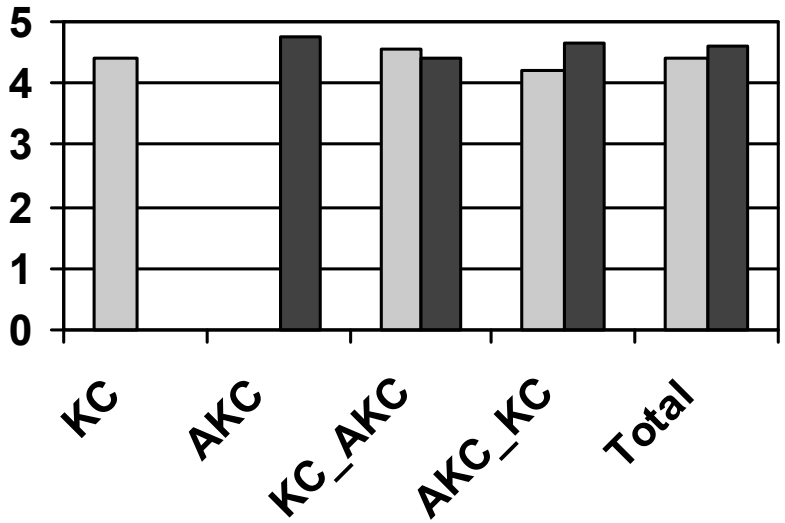
Test type	No. of groups	No. of Graders				
		1st	2nd	3rd	4th	Σ
KC	13	6	6	11	10	33
AKC	12	8	8	8	9	33
KC/AKC	8	2	4	5	3	14
AKC/KC	6	6	6	3	8	23
Σ	39	22	24	27	30	103

Interviewing the Children

- Initial interview (name, age, possession of devices, etc.)
- Open questions (stories, what they liked, disliked, etc.)
- Questionnaire (fun, educational content)

Children's Rating of Fun

- How much did you like playing with…
  - KC: 4.4
  - AKC: 4.6



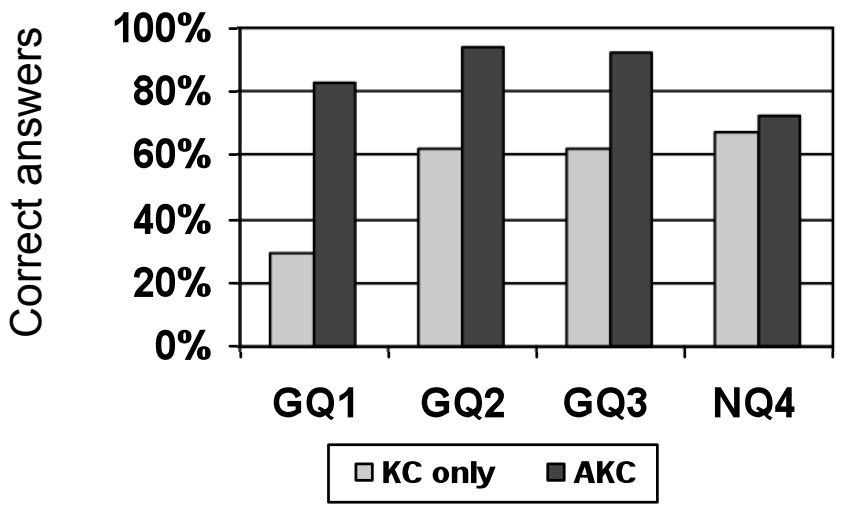
- Direct comparison (37 children):
  - 21 AKC (57%), 6 equal, 10 KC
  - 27 would play again with the AKC (73%)
- AKC compared with…
  - …traditional toys: 33 out of 33 said "more fun"
  - …computer/video games: 32 out of 33 said "more fun"

Play Behavior

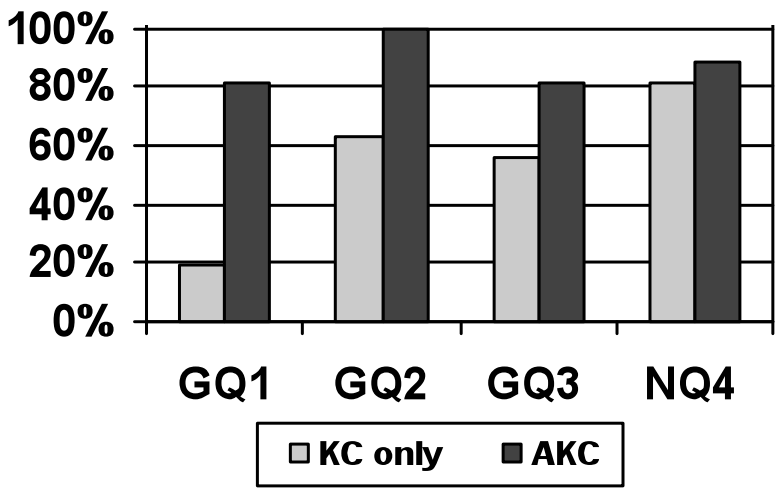
- Some children just 'cracked up' and laughed.
- Some children directly replied to the figures' utterance:
  - 1a: Figure: I'm the golden knight.
  - 1b: Child: Hello golden knight.
  - 2a: Figure: I need a new sword, which costs seven cows.
  - 2b: Child: I don't have seven cows…
  - 3a: Figure: I was in the pantry; we have enough bread for the winter.
  - 3b: Child: Where is the pantry?
- Some children responded indirectly, e.g., "let's take the golden knight".
- Some children ignored or disregarded it.

Questions (Educational Content)

- GQ1: What was the most important food in the Middle Ages? (Answers: bread, meat, potatoes)
- NQ1: What was the royal color? (Answers: red, yellow, green)



Immediate - Older Group



Delayed - Older Group

CONCLUSIONS

Contributions

- Theoretical foundation
- Digital augmentation
  - Process model
  - Design guidelines
- Two exemplary prototypes / use case
  - Warhammer 41K
  - The Augmented Knight's Castle
- AKC User Study

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