Designing for Collaborative Co-Located Multi-Display Environments

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Summary & Learning goals

The students are introduced to the concept of Multi-display environments (MDE), i.e., the coupling of several displays together to form a shared interactive environment. The concept is described through a taxonomy categorising MDE:s and illustrative cases.

Learning goals:

- recognize multi-display environments (MDE:s)
- describe relevant factors influencing the design of MDE:s
- analyse the design of MDE:s.
- reflect on the potential consequences of MDE:s for collaborative interaction.

Recommended readings

- F. Garcia-Sanjuan, J. Jaen and V. Nacher, Toward a General Conceptualization of Multi-Display Environments, Frontiers in ICT 2016 Vol. 3, https://www.frontiersin.org/article/10.3389/fict.2016.00020
- Weiser, M. (1991). The Computer for the 21 st Century. Scientific American, 265(3), 94–105. http://www.jstor.org/stable/24938718

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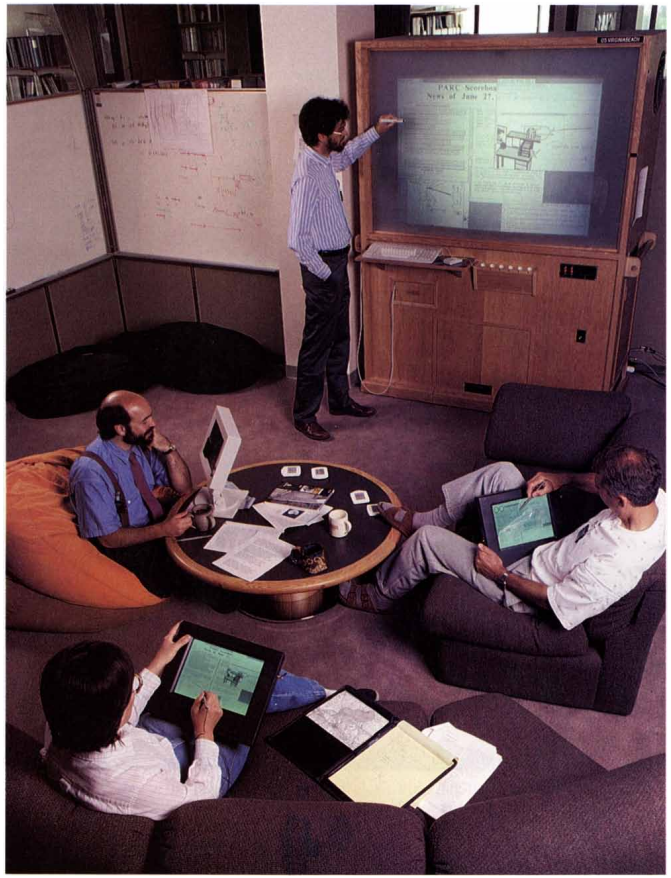
- Definition – Multi-Display Environment
- Examples
- A taxonomy describing properties of MDE:s
- Perspectives
  - Topology
  - Coupling
  - Interaction
- Case 4in1
- Summary

The Computer for the 21st century

“Prototype tabs, pads and boards are just the beginning of ubiquitous computing. The real power of the concept comes not from any one of these devices – it emerges from the interaction of all of them”

Mark Weiser, 1991

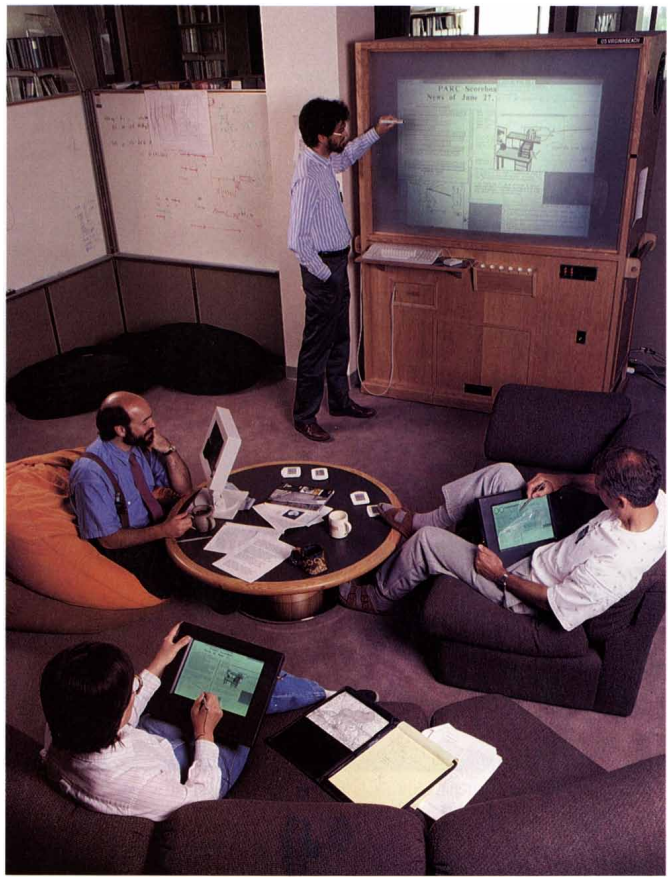
30+ year old idea of combining several displays allowing new possibilities



The Computer for the 21st century

- Ubiquitous Computing
  - Computing everywhere
  - From 1 person 1 device
  - To 1 person many devices
  - All interacting
    - Collaborative
    - Picture from 1991

- Many different experiments have been carried out
- One-device-one-display-one-user still dominating context
- Do you agree?



Multi-Display Environments

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Mark Weiser, 1991

30+ year old idea of combining several displays allowing new possibilities

Multi-Display Environments

- ”we consider as a multi-display or multi-surface environment a ubiquitous interactive computing system composed of several displays (or surfaces) with digital content that are located in the same physical space and have a “coupling” relationship to each other, the users interacting with the system, and the objects used for this purpose. The way surfaces are arranged and coupled determines how users perceive them as a whole, and how interactions should happen.”
- Coupling – binding of 2 or more entities to provide a set of functions they cannot provide indivdually

Garcia-Sanjuan, F., et al. (2016). Toward a General Conceptualization of Multi-Display Environments.

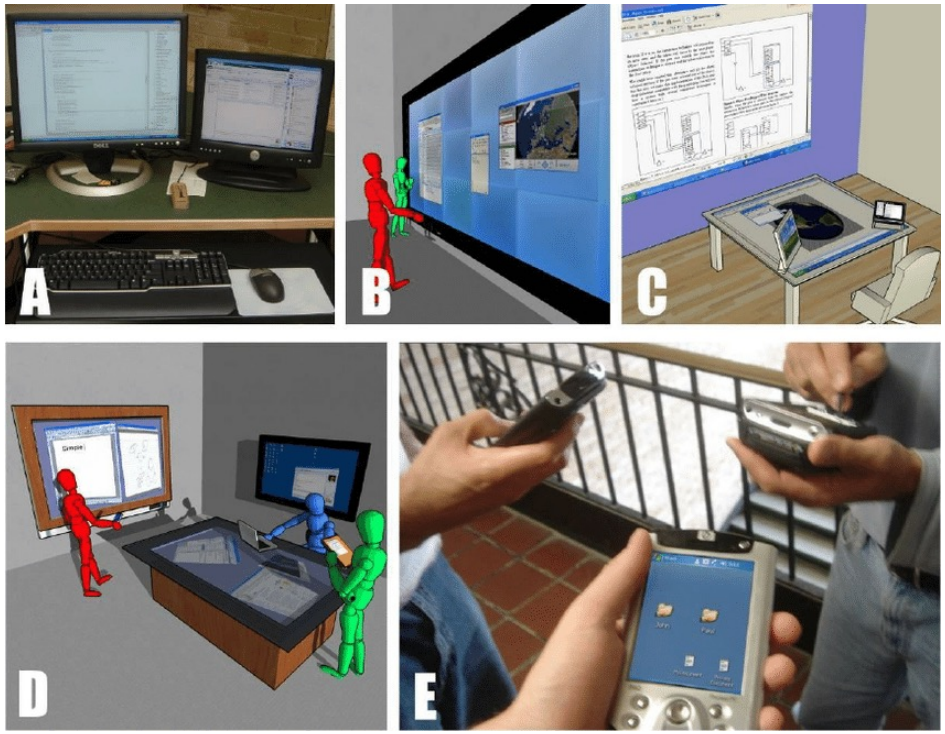
Multi-Display Environments

- Break down
  - Interactive computing system
  - *Several* displays
  - Showing digital content
  - Located in the *same physical space*
  - *Coupling* relationship
    - Displays
    - Users
    - Objects used for interaction

- As a whole – an interactive environment

Garcia-Sanjuan, F., et al. (2016). Toward a General Conceptualization of Multi-Display Environments.

Examples

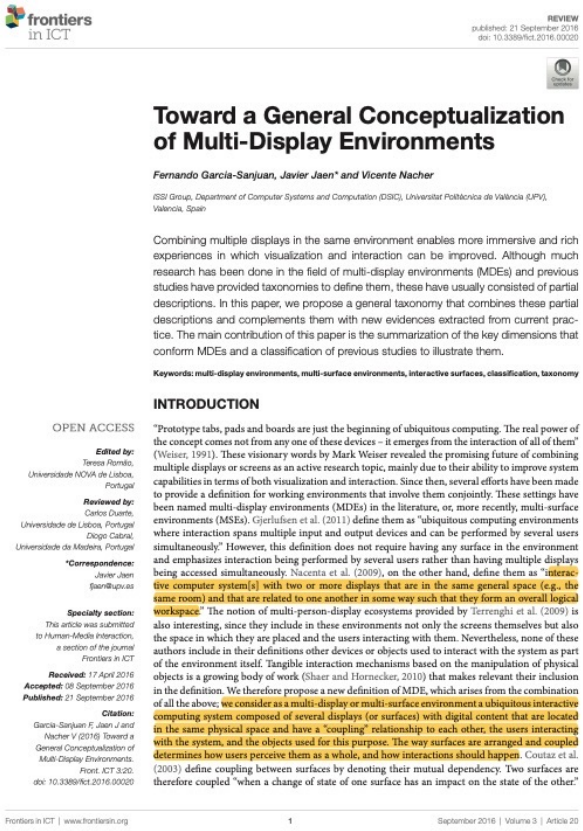


- A - Several monitors
- B - Composite display
- C - Advanced office
- D - Meeting room
- E - Linked mobiles

Nacenta, M. A., Gutwin, C., Aliakseyeu, D., & Subramanian, S. (2009). There and Back Again: Cross-Display Object Movement in Multi-Display Environments. *Human–Computer Interaction, 24*(1-2), 170-229.

Mapping out Multi-Display Environments (MDE:s)

- A taxonomy of MDE:s
  - Maps out the design space
- Description of MDE:s along 3 perspectives
- *Topology*
- *Coupling*
- *Interaction*



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Toward a General Conceptualization of Multi-Display Environments

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Combining multiple displays in the same environment enables more immersive and rich experiences in which visualization and interaction can be improved. Although much research has been done in the field of multi-display environments (MDEs) and previous studies have provided taxonomies to define them, these have usually consisted of partial descriptions. In this paper, we propose a general taxonomy that combines these partial descriptions and complements them with new evidences extracted from current practice. The main contribution of this paper is the summarization of the key dimensions that conform MDEs and a classification of previous studies to illustrate them.

Keywords: multi-display environments, multi-surface environments, interactive surfaces, classification, taxonomy

INTRODUCTION

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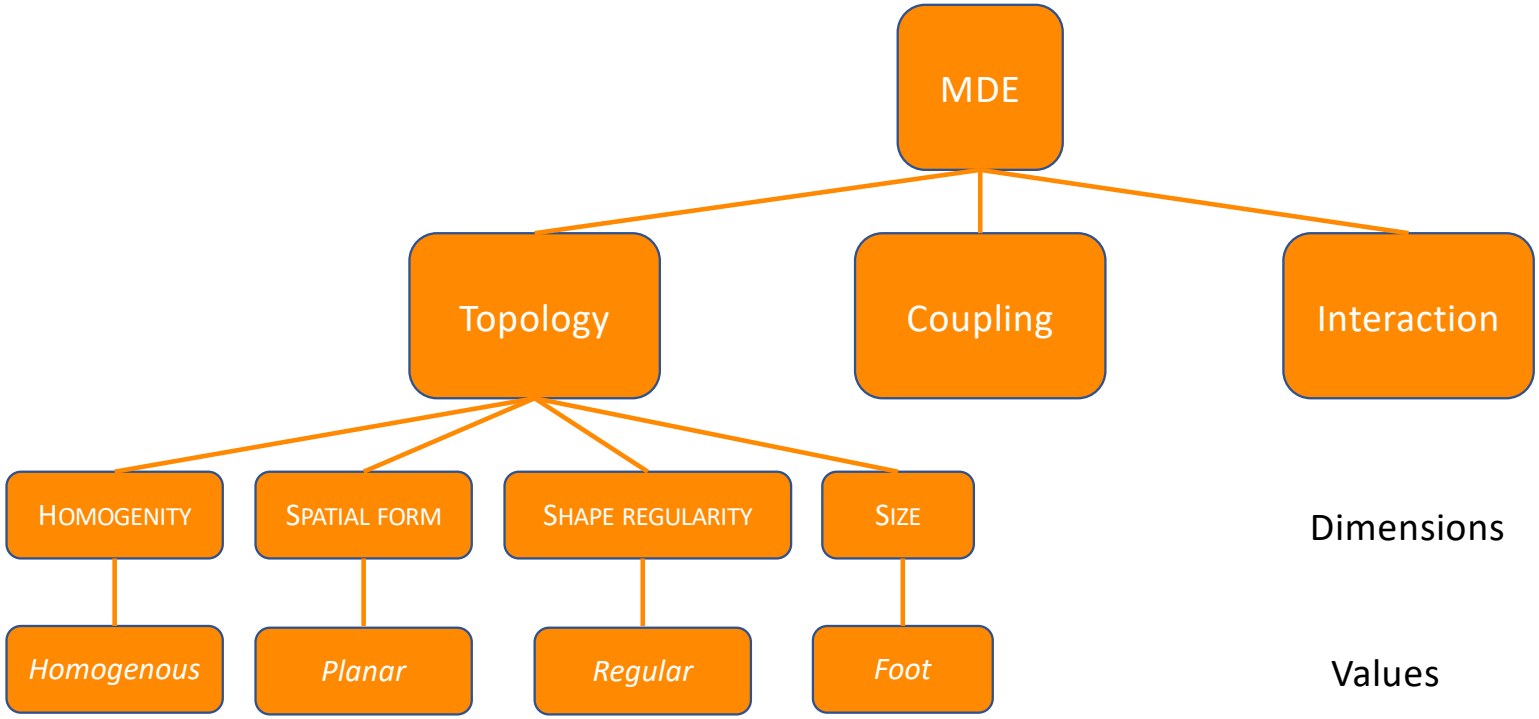
"Prototype tabs, pads and boards are just the beginning of ubiquitous computing. The real power of the concept comes not from any one of these devices – it emerges from the interaction of all of them" (Weiser, 1991). These visionary words by Mark Weiser revealed the promising future of combining multiple displays or screens as an active research topic, mainly due to their ability to improve system capabilities in terms of both visualization and interaction. Since then, several efforts have been made to provide a definition for working environments that involve them conjointly. These settings have been named multi-display environments (MDEs) in the literature, or, more recently, multi-surface environments (MSEs). Gjerlufsen et al. (2011) define them as "ubiquitous computing environments where interaction spans multiple input and output devices and can be performed by several users simultaneously." However, this definition does not require having any surface in the environment and emphasizes interaction being performed by several users rather than having multiple displays being accessed simultaneously. Nacenta et al. (2009), on the other hand, define them as "interactive computer system[s] with two or more displays that are in the same general space (e.g., the same room) and that are related to one another in some way such that they form an overall logical workspace." The notion of multi-person-display ecosystems provided by Terrenghi et al. (2009) is also interesting, since they include in these environments not only the screens themselves but also the space in which they are placed and the users interacting with them. Nevertheless, none of these authors include in their definitions other devices or objects used to interact with the system as part of the environment itself. Tangible interaction mechanisms based on the manipulation of physical objects is a growing body of work (Shaer and Hornecker, 2010) that makes relevant their inclusion in the definition. We therefore propose a new definition of MDE, which arises from the combination of all the above; we consider as a multi-display or multi-surface environment a ubiquitous interactive computing system composed of several displays (or surfaces) with digital content that are located in the same physical space and have a "coupling" relationship to each other, the users interacting with the system, and the objects used for this purpose. The way surfaces are arranged and coupled determines how users perceive them as a whole, and how interactions should happen. Coutaz et al. (2003) define coupling between surfaces by denoting their mutual dependency. Two surfaces are therefore coupled "when a change of state of one surface has an impact on the state of the other."

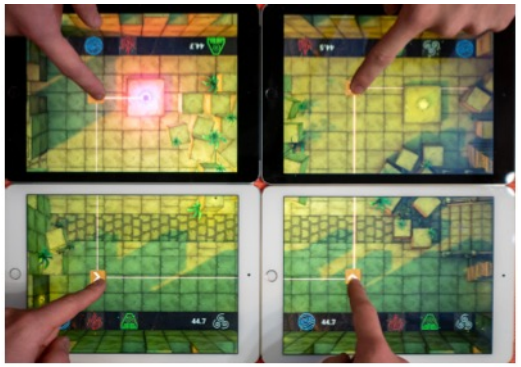
MDE Taxonomy



Perspectives

Dimensions

Values



Topology Perspective

Describes the dimensions relative to the physical appearance of the MDE.

- HOMOGENEITY – *homogeneous*, *heterogeneous*
- *SPATIAL FORM* – *planar, volumetric*
- SHAPE REGULARITY – *regular, irregular*
- SIZE – *inch, foot, yard, perch, chain*
- MOBILITY – *fixed, mobile*
- SCALABILITY – *bounded, unbounded*

Example

- Topology
  - HOMOGENEITY – *homogeneous*
  - *SPATIAL FORM* – *planar*
  - SHAPE REGULARITY – *irregular*
  - SIZE – *yard*

Coupling Perpective

Describes the dimensions related to how the displays inte the MDE connect to each other.

- CREATION - *implicit, manual, assisted, automatic*
- MUTABILITY – *static, dynamic*
- LOGICAL VIEW – *discrete, redundant, extended-continuous, extended-discontinuous*
- PRIVACY - *private, personal, public*

Example

- Topology
  - HOMOGENEITY – *heterogeneous*
  - *SPATIAL FORM* – *volumetric*
  - SHAPE REGULARITY – *regular*
  - SIZE – *perch*
- Coupling
  - MUTABILITY – *static*
  - LOGICAL VIEW – *redundant*

Interaction Perspective

Describes the available interaction modes once the devices have been organized and coupled together

- INTERACTION AVAILABILITY – *inexistent, partial, total*
- INPUT DIRECTNESS – *direct, indirect*
- INTERACTION MEDIUM – *on-device, around-device*
- INTERACTION INSTRUMENTS - *body-based, surface-based, tangible*
  - tangible includes e.g., mice and keyboards
- INPUT CONTINUITY – *punctual, gestural*

Example

- Topology
  - HOMOGENEITY – *homogeneous*
  - *SPATIAL FORM – volumetric*
  - SHAPE REGULARITY – *irregular*
  - SIZE – *foot*
- Interaction
  - INTERACTION AVAILABILITY – *total*
  - INPUT DIRECTNESSS – *direct*
  - INTERACTION MEDIUM – *on-device*
  - INTERACTION INSTRUMENTS - *surface-based*
  - INPUT CONTINUITY – *punctual, gestural*

Siftables: https://www.youtube.com/watch?v=vbwzBBHtNGI

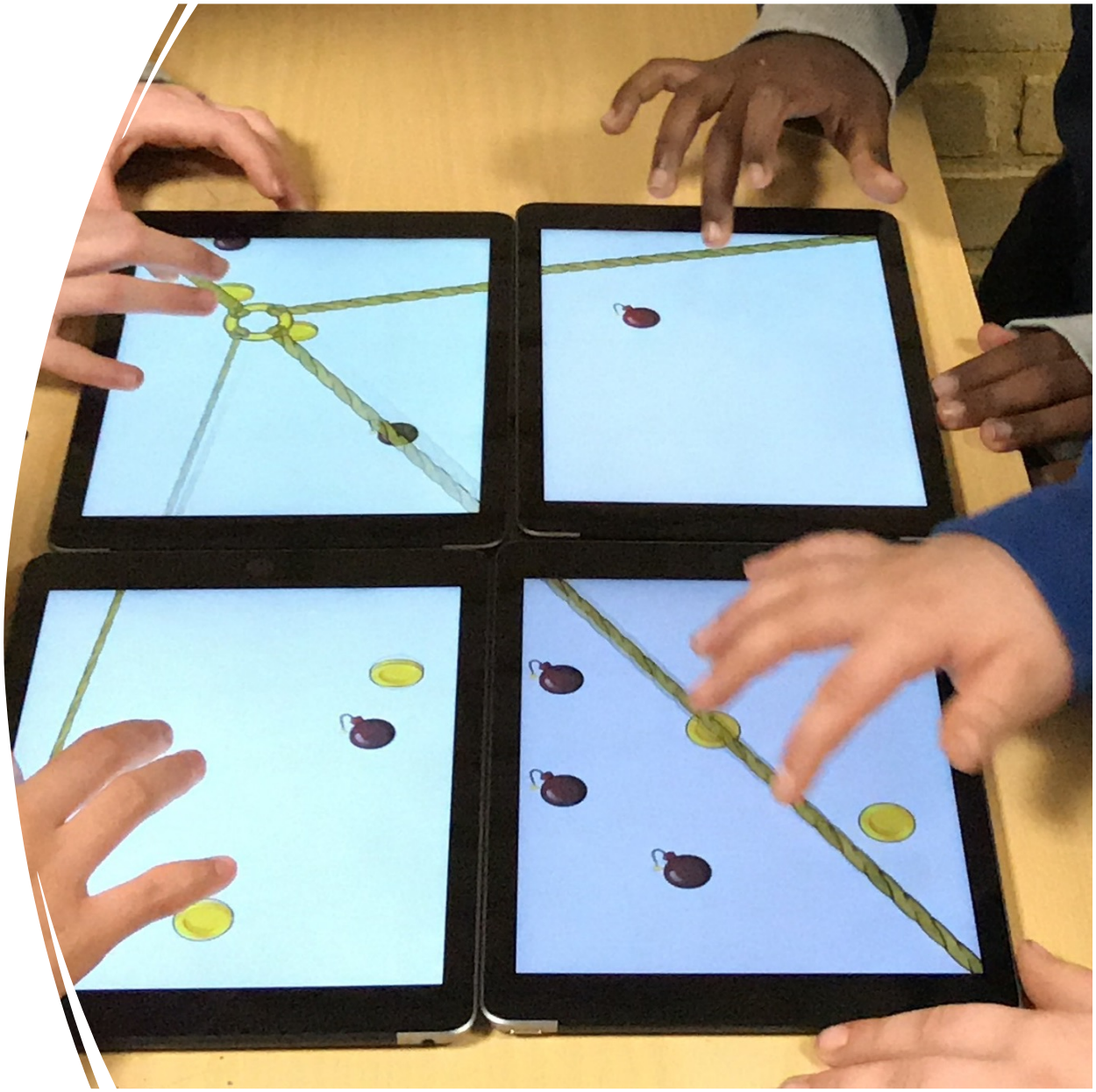
Why is the Taxonomy Useful?

- Analysis & Ideation

- Analysis
  - Categorize
  - Compare
  - …
- Ideation
  - Provide ideas
  - Pick dimensions from the perspectives and ideate
    - E.g., *planar, foot, on-device* or *volumetric, yard, tangible*

4in1 Activities – a collaborative Multi-Display Environment

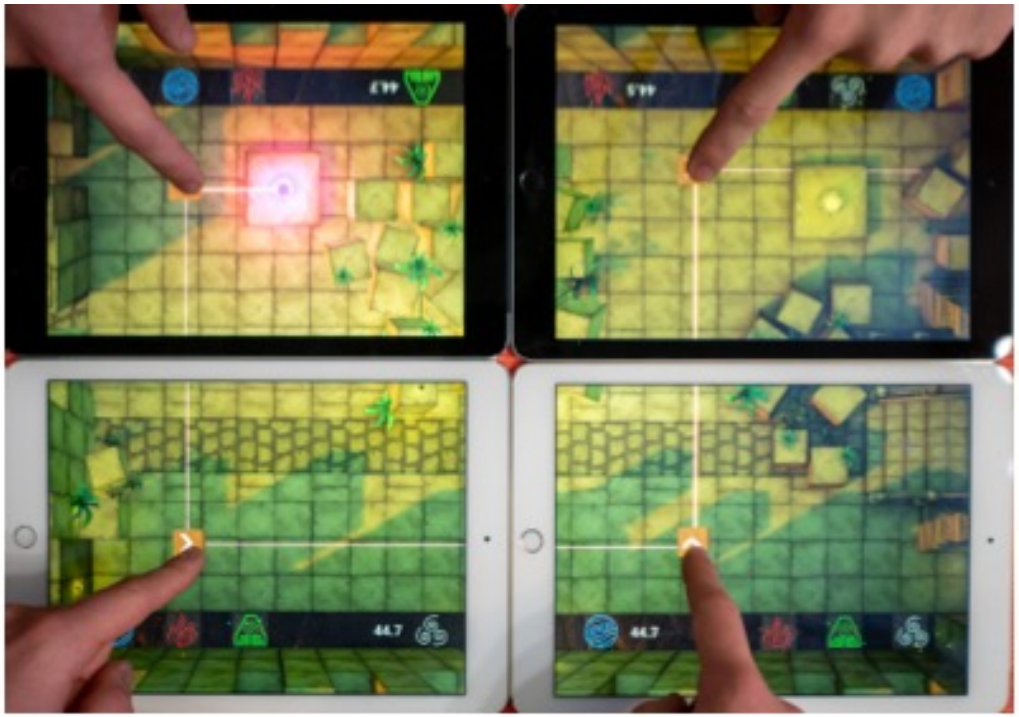
- A 4in1 activity is defined as an application involving 4 participants that play out on 4 tablets coupled together to form one large display
- Can function as a low-cost tabletop solution



Barendregt, W., Börjesson, P., Eriksson, E., & Torgersson, O. (2017). StringForce: A Forced Collaborative Interaction Game for Special Education. In Proceedings of the 2017 Conference on Interaction Design and Children (IDC '17).

4in1 - Bursting the Mobile Bubble

- Use tablets to do things together
- Laser Lunacy
  - Course project
  - Bachelor thesis



- Movie
  - https://www.youtube.com/watch?v=5uSsxlLu1zk&feature=youtu.be

Design of 4in1 Activities

- 4 co-located participants
- The spatial organisation of tablets induces expecations of shared use
- All participants have the focus on the same object (the tablets)
- A shared goal is established between the participants
- Assymetry between particpants in terms of different capabilities can be used giving them different roles but the efforts of all participants are accounted for and valued
- The design should encourage human-human interaction between participants

Analysis of 4in1 Using the Framework

Perspective	Dimension	State(s)
TOPOLOGY	HOMOGENITY	*homogeneous*
	SPATIAL FORM	*planar*
	SHAPE REGULARITY	*regular*
	SIZE	*foot,yard*
	MOBILITY	*mobile*
	SCALABILITY	*bounded*
COUPLING	CREATION	*assisted*
	MUTABILITY	*static*
	LOGICAL VIEW	*extended-continuous*
INTERACTION	PRIVACY	*public*
	INTERACTION AVAILABILITY	*total*
	INPUT DIRECTNESS	*direct*
	INTERACTION MEDIUM	*on-device*
	INTERACTION INSTRUMENTS	*surface-based*
	INPUT CONTINUITY	*punctual, gestural*

Topology

Perspective	Dimension	State(s)
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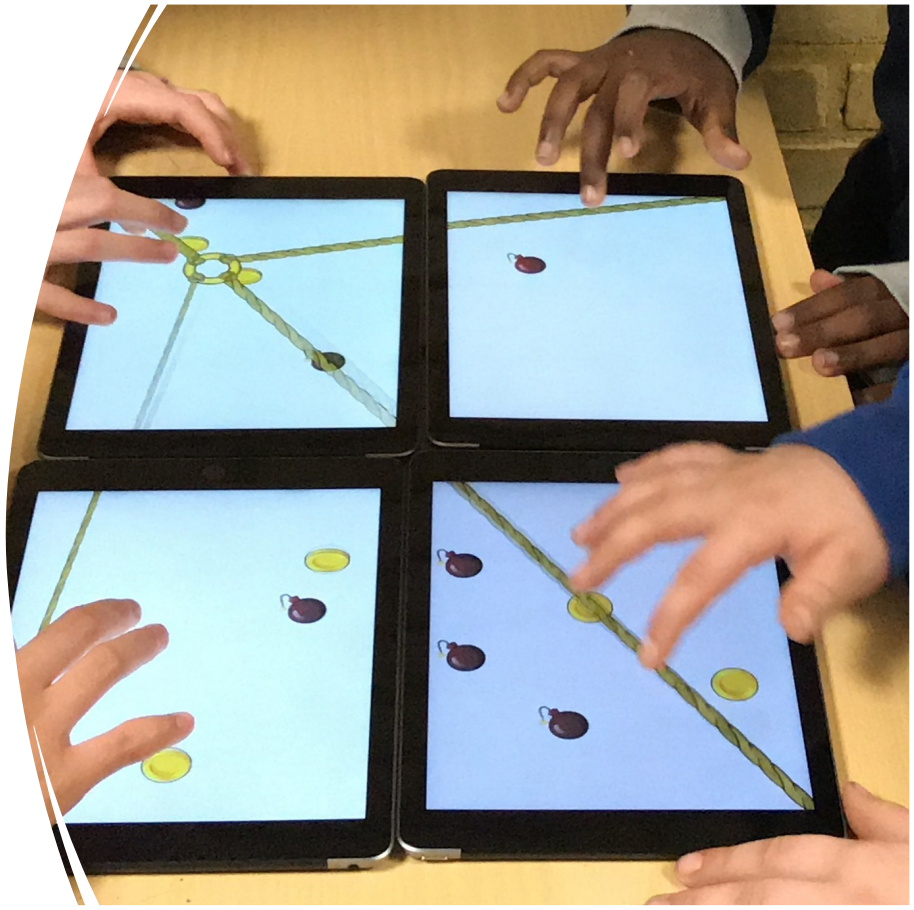
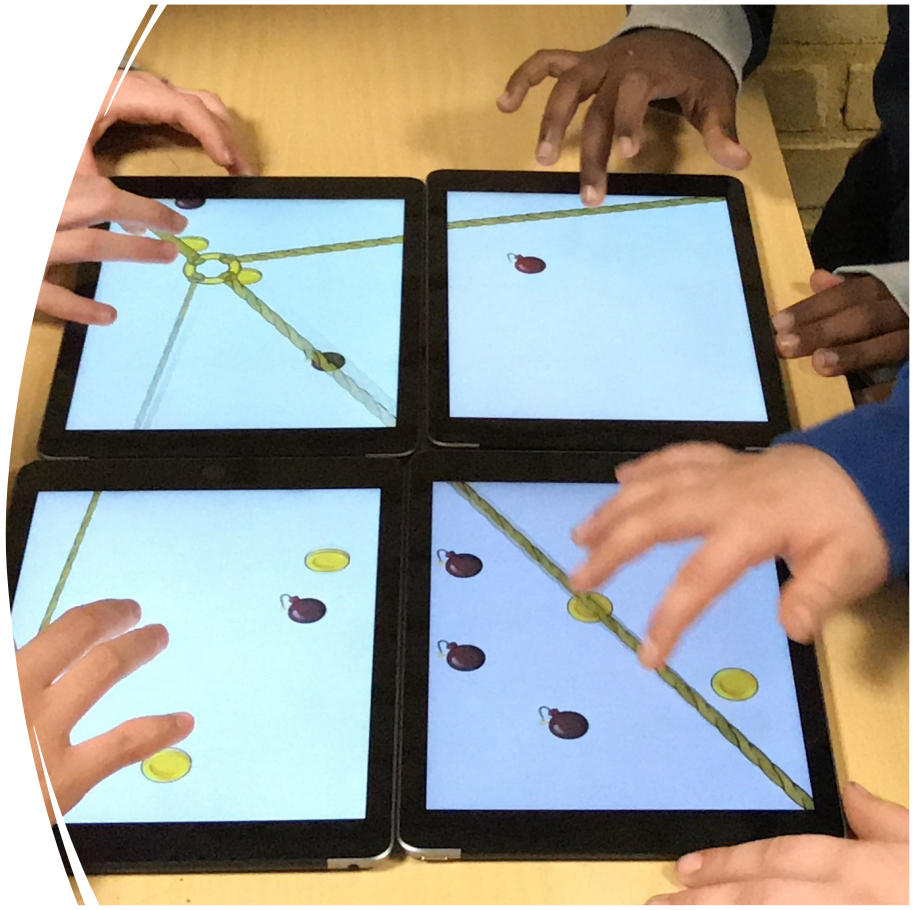


Coupling

Perspective	Dimension	State(s)
COUPLING	CREATION	*assisted*
	MUTABILITY	*static*
	LOGICAL VIEW	*extended-continuous*



Interaction

Perspective	Dimension	State(s)
INTERACTION	PRIVACY	*public*
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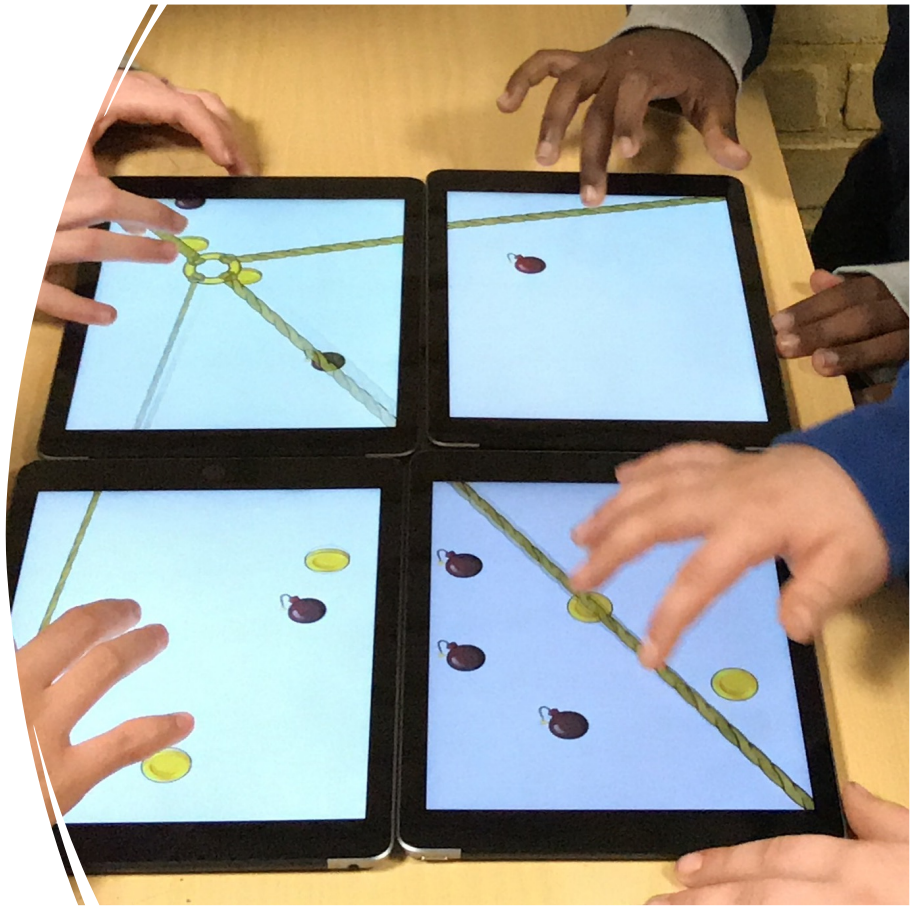
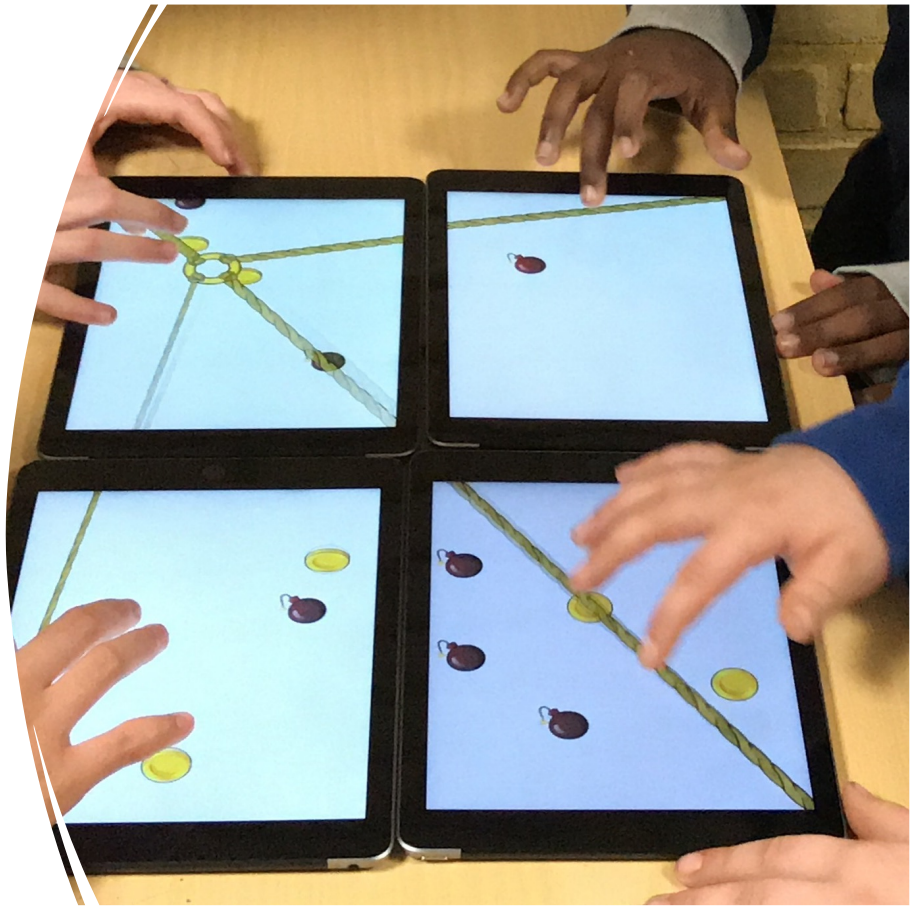


Reflection

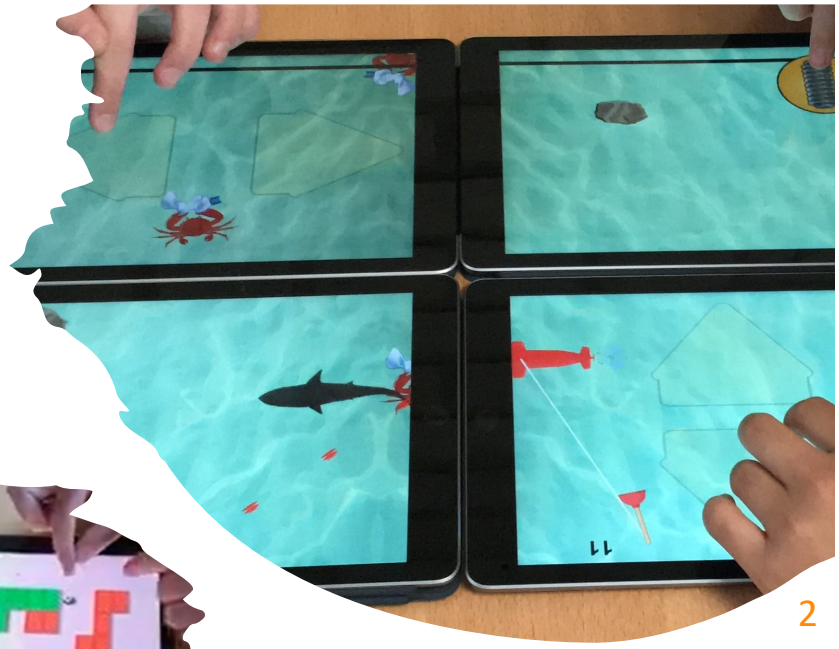
- Take a few minutes to reflect on the collaborative MDE 4in1
- Some things to discuss:
  - Is there a potential in combining devices?
  - Can you think of a scenario for
    - Work?
    - Leisure?
  - Weiser saw this kind of use of combined displays 30 years ago
    - Was he right?
    - What will it be 30 years from now?

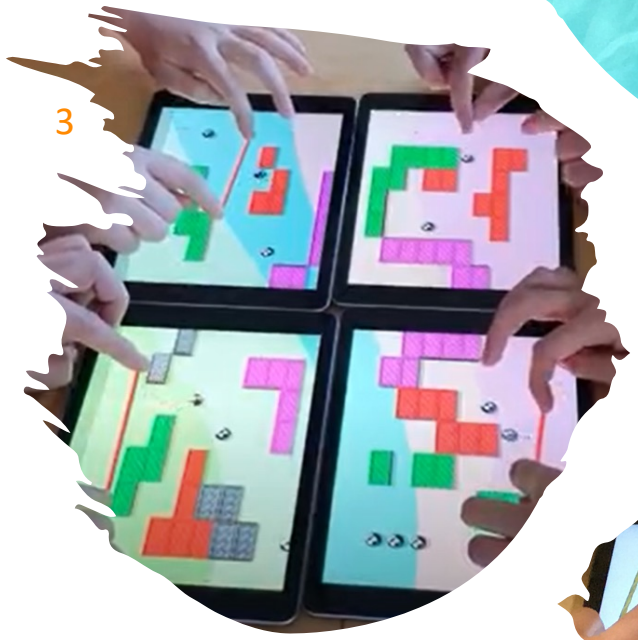


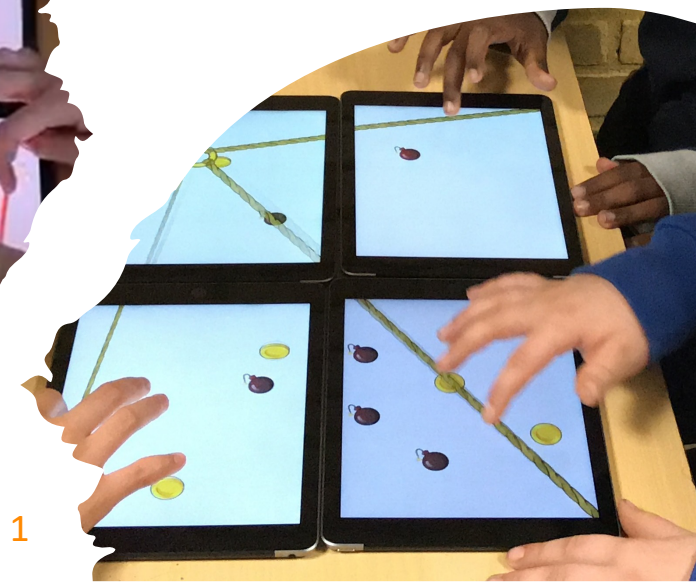
4in1 Sample Applications

- So far Games

- StringForce (1)
- Subventure (2)
- QuadroPong (3)

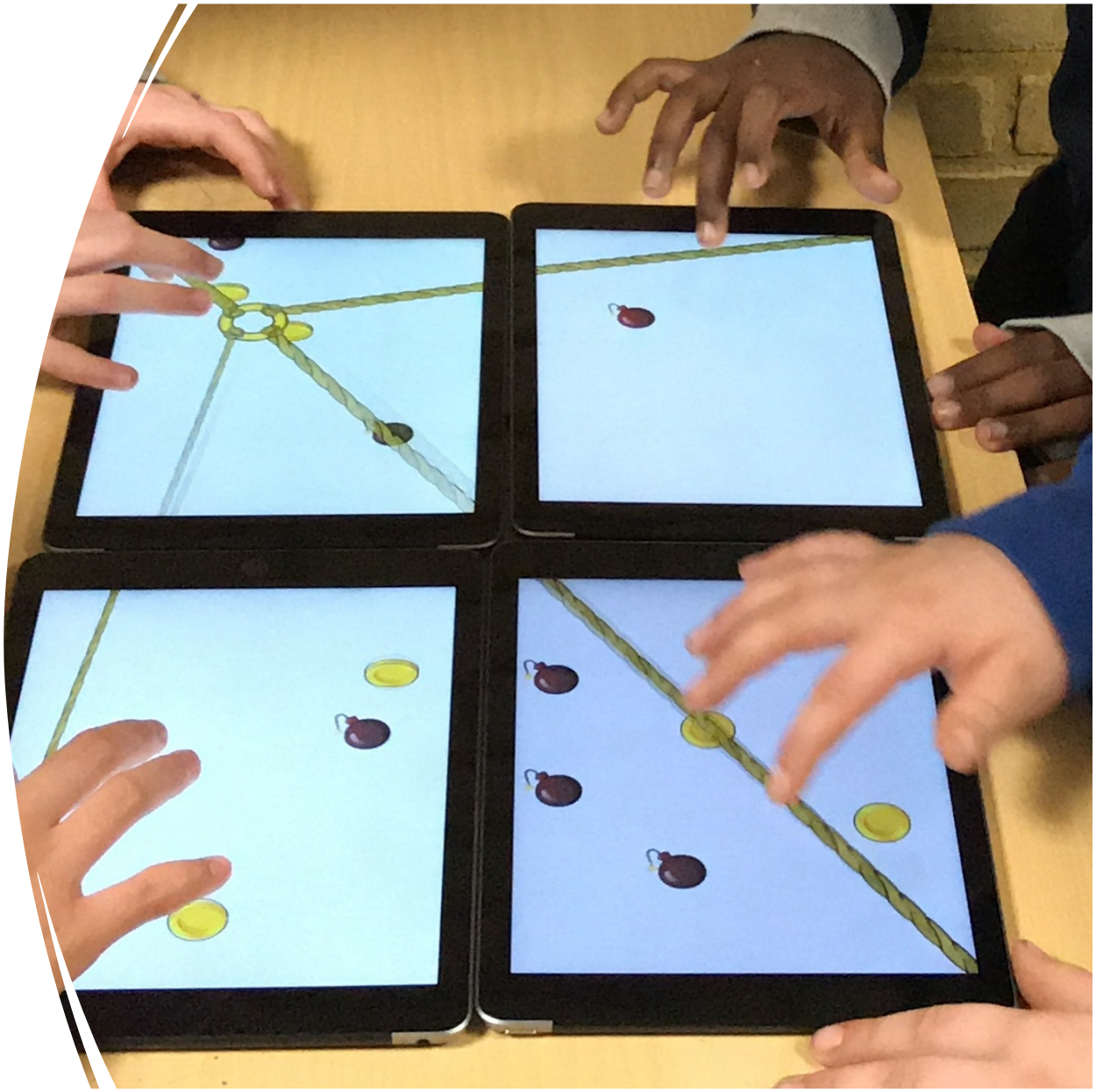






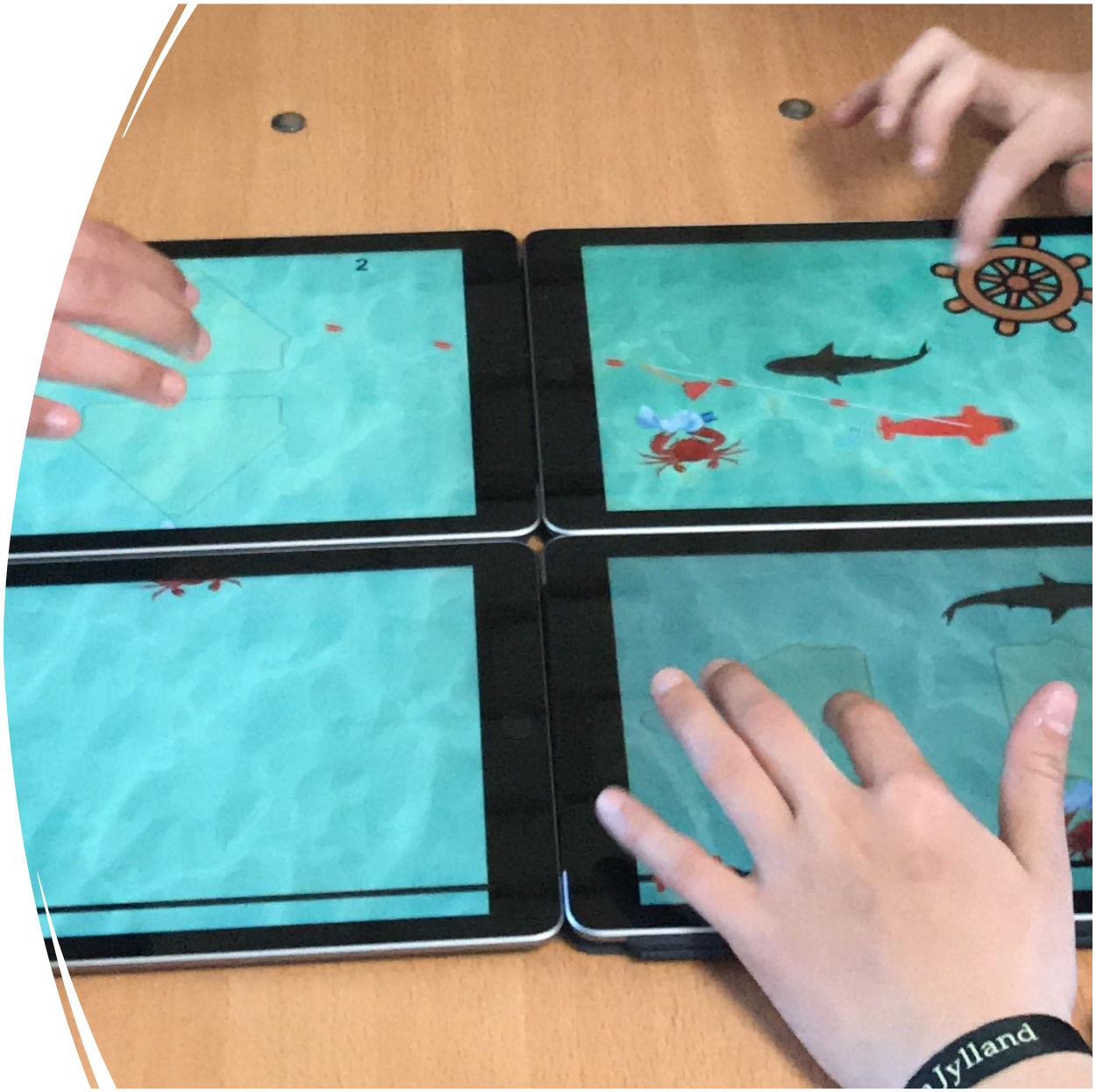
StringForce

- Shared goal – catch coins & avoid bombs
- Collaborative action – move ring by pulling and releasing rope
- Coordination through verbal communication
- Symmetrical interaction
  - All players have the same skills
- Fast-paced



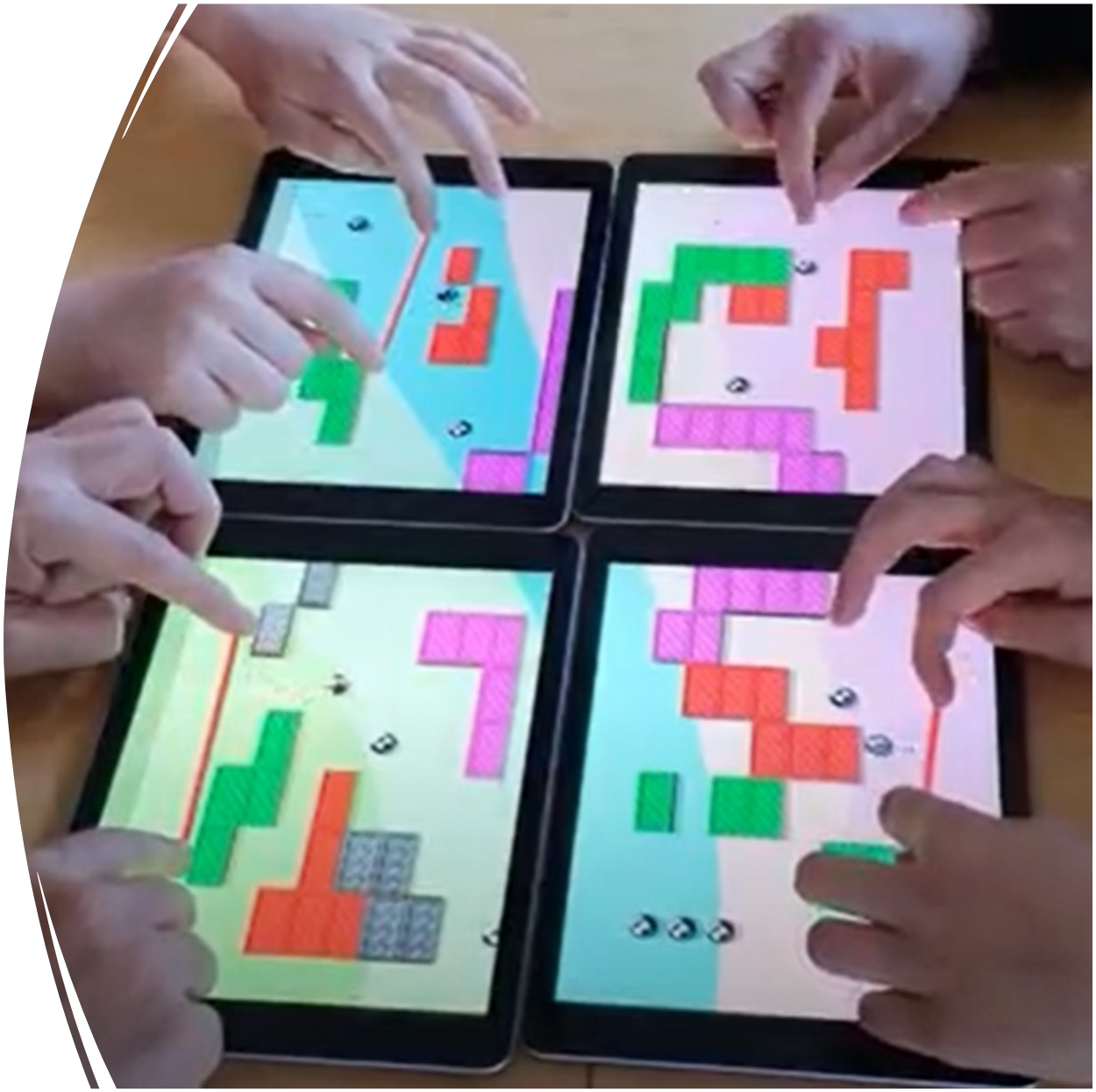
Subventure

- Shared goal – collect trash
- Collaborative action – move submarine using controls
- Coordination through verbal communication
- Assymetrical interaction– each person has one task
- Medium paced



Quadropong

- Shared goal – clear the board
- No collaborative action
- Order and resources matter
- Coordination through verbal communication
- Explores interdependency between players' actions



Summary

- Combining many different devices is on old idea
- Many different experiments have been carried out
- One-device-one-display-one-user still dominating context
- Taxonomy helps organising analysis and ideation
  - Topology
  - Coupling
  - Interaction

- 4in1 Activities one concrete example
  - Alternative low-cost tabletop
  - Fully realizable using existing technologies

- Endless possibilities

References

- Barendregt, W., Börjesson, P., Eriksson, E., & Torgersson, O. (2017). StringForce: A Forced Collaborative Interaction Game for Special Education. In Proceedings of the 2017 Conference on Interaction Design and Children (IDC '17). Association for Computing Machinery, New York, NY, USA, 713–716. https://doi.org/10.1145/3078072.3091987
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Thanks for listening