Mobile devices transforming the museum experience: **O**pportunistic **U**ser **I**nterfaces to exhibits (**O-UI**s)

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Problem Statement

How can learning technologies — tools, spaces, and places — be designed to support learners within and across environments?

How can technology-based *exhibits* be designed to support *groups* of learners *within* museum environments?

Computer kiosks have gradually been giving way to large shared displays to better support groups of visitors


Trackball


Touchscreen

Computer Kiosks


Sensor/Camera input


Kiosk input

Large Shared Displays

Preserving richness of input difficult when scaling up for groups: input complexity is reduced or limited to one visitor at a time

or access must be built in, which limits scalability


Large shared input opportunity


Replicated kiosk opportunities

alternatively, access can be supported through personal devices


Mobile input opportunities
O-UIs

How can *mobile devices* be designed to support *groups* of learners *within* a museum *exhibit*?

Collaborative/cooperative learning in museums requires interaction with both exhibit and companions

Other work with mobiles in museums:

Mobile Guides	Mobile "Treasure Hunts"	Mobile "Worksheets"	Mobile Polls/Tags
Tend to be solitary Supply extra information to visitors: • text (e.g., digital label, how-tos) • audio (e.g., audio tour, music) • visual (e.g., videos, augmented reality) Examples: *Electronic Guidebook*[1] *Sotto Voce*[2] *PEACH*[3]	Support groups via task interdependence Encourage visiting many/new exhibits Hunt structured around narrative or game Examples: *Mystery at the Museum*[4] QR-Code treasure hunt[5] *Musex*[6]	Tend to be individual or pair-based Tend to be linked to school curricula Have varying degrees of open-endedness Examples: *LEGS*[7] Connecting classrooms to aquarium visits [8] *Zydeco*[9]	Allow individual expression (e.g., SMS, tag) Expressions are posted publicly Can involve voting on issues Can involve labeling artifacts / exhibits Examples: *SNSE*[10] MobiTags [11]

How might these uses of mobiles support collaborative learning in museums?

+ Can adapt delivered content to visitor + Replicates free-choice nature of museum - Rich interaction can lead to inattention to companions & surroundings (heads-down effect)	+ Task interdependence promotes collaboration + Game motivates visitors - To support content acquisition, activity should be more than a superficial framing	+ Directly support acquisition of content + Small challenges/feedback encourage talk - Often require scaffolding in classrooms - Content *can* be superficial owing to limits on free-responses (e.g., multiple choice)	+ Interaction with exhibit itself can promote integration of ideas + Shared context supports shared experience - Visitors can be inhibited about "performing" in public space

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5. Celepidor, U. B., Medaglia, C. M., Perrone, A., Marsico, M. D., & Romano, G. D. (2009). A museum mobile game for children using QR-codes. In *Proc. IDC 2009*, Como, Italy. (pp. 282-283). ACM.
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10. Bressler, D. M. (2005). Science Now, Science Everywhere: Liberty Science Center's Mobile Learning Companion (White paper): Liberty Science Center.
11. Cosley, D., Baxter, J., Lee, S., Alson, B., Nomura, S., Adams, P., Sarabu, C., and Gay, G. (2009) A tag in the hand: supporting semantic, social, and spatial navigation in museums. In *Proc CHI '09*, 1953-1962.

3 Studies of Opportunistic User Interfaces

Intended to address different aspects of the question: How can *O-UIs* be designed to support *collaborative learning* within a museum *exhibit* ?

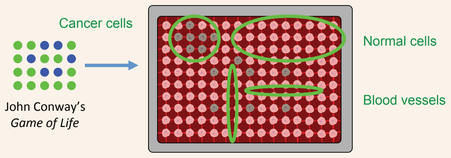
Incorporated aspects from prior work in museums (large shared display, ample seating) with questions concerning effect on collaboration raised by mobile research (impact of heads-down effect, impact of task interdependency, impact of input ease)

Does UI complexity affect collaboration?

Lab-based within-subject experiment
1 interface (non-interdependent)
2 conditions: high vs. low UI complexity
11 groups, ~3/group

Activity:

Shared simulation of complex system: cancer growth
3 cellular automata: healthy cells, cancer cells, blood vessels
Automata obey rule sets that result in tumor growth, metastasis
Visitors fight cancer using interventions derived from medicine
Goal is to work together to eliminate cancer



Conditions:

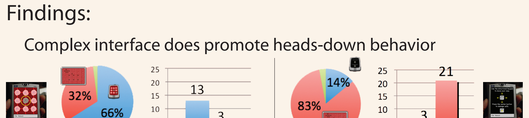
Identical roles: surgery
Interfaces differ in Input-Output complexity
Complex output: zoomed-in view of shared screen, updates frequently, stylus input
No output: static instructions only, hardware button input


Complex Output Stylus Input


No Output Button Input

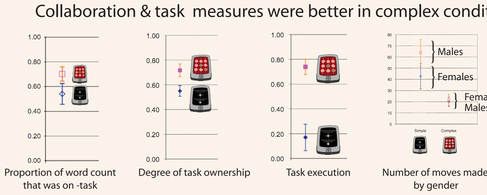
Findings:

Complex interface does promote heads-down behavior



BUT

Collaboration & task measures were better in complex condition



Implications:

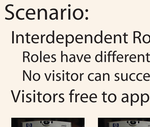
Heads-down behavior doesn't impede task execution in this case
More complex interfaces promoted more equity & collaboration
- Perhaps a sense of private space?
- Perhaps "friction" - complex input slowed down users - promoted more careful participation?

Does task interdependency affect collaboration?

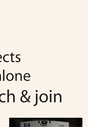
in situ observational study
3 interdependent interfaces
31 groups, ~3/group

Scenario:

Interdependent Roles
Roles have different effects
No visitor can succeed alone
Visitors free to approach & join


Radiation

Proton Beam


Surgery

Still from video taken on Exploratorium floor

This case: After watching **A** and **B** play for about a minute, **C** and **D** join **A** and **B**, who have already played several rounds.

Findings:

B notices **C**'s confusion & explains part of shared context but doesn't add key salient detail (grey = cancer)
- [00:00:07.06] *B leans over and notices that participant C has a different interface {and, consequently, role}*
- [00:00:16.12] B says: "**every one of them is all grey**" *to C, indicating that the cells in question are all cancerous*

A uses prior experience to suggest strategy, demonstrates understanding of cumulative radiation
- [00:00:32.26] A says: "**Not too much radiation this time**"

A begins to lead activity, declaring intentions & querying partners
- [00:00:38.24] A says: "**I'll get this**"
- [00:00:42.07] A says: "**Radiation [garbled] the area**"
- [00:00:58.06] A says: "**[C's name] - is that you who just got above me?**"
- [00:01:02.00] C says: "**I'm blue - right?**"

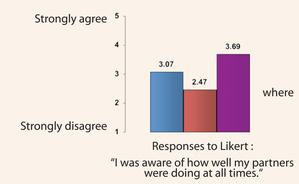
B again assumes a tutorial role when **D** expresses confusion
- [00:01:03.28] D says: "**what am I supposed to be doing?**"
- [00:01:07.09] *B explains to D his on-screen representation of identity, his user interface controls, what his responsibilities within the game are, and uses gestures to help D make the connection between personal and shared visual representations [edited for space].*
- [00:01:19.29] D says: "**are we supposed to be watching the TV?**"

A has been monitoring novice partner **C**'s actions & provides positive feedback. **C** uses the opening to ask for help from **A**
- [00:01:21.04] A says: "**[C's name] look you got one over there**"
- [00:01:23.13] *C realizes that A is playing the same role (surgery) and uses body language to indicate that she needs help figuring out how to interact with the simulation. A also leans forward and gives C direct instruction* - "**You draw lines, circles around the...the grayish looking ones**"

B has been monitoring novice partner **D**'s actions & provides positive feedback. **D** begins reporting his progress to group
- [00:01:34.00] *B points out that D has been using proton radiation, assigning credit for eliminating a tumor*
- [00:01:35.01][00:01:39.00][00:01:45.03] *D keeps a running commentary on his progress at mastering his tool:* "**I missed**" "**I missed again**" "**I got it!**"

A has been monitoring experienced partner **B** & provides feedback when radiation mistake is made. Unclear if **B** understands role of radiation in patient death; **C** & **D** are oblivious to exchange
- [00:01:51.10] *B accidentally irradiates a selection of healthy tissue; A understands immediately what has happened, as she is operating in the same region, and her reaction cues B into her mistake. Much of the meaning of this interaction is offloaded onto the shared representation via gesture; very little conversation is used*
- [00:01:59.17] *C is getting the hang of it; she says:* "**I got the bad ones!**" *to indicate to her partners that she is now contributing to the joint endeavor*

A uses her (unique?) understanding of cumulative radiation to predict outcome of simulation
- [00:02:04.12] *A has come to understand the role of cumulative radiation on patient mortality, and says:* "**watch this patient is about to die**"



Responses to Likert : "I was aware of how well my partners were doing at all times."

Implications:

Interdependent roles promote inter-group awareness
- That awareness often translates into assistance

Both shared display and devices served as anchors for communication
Allowing participants to join at any time facilitates collaboration
Collaborative episodes focused on functionality, not understanding
- Many missed opportunities for learning; can scaffolding help?

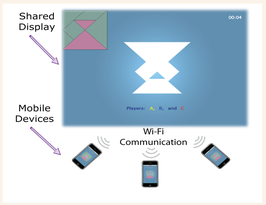
Does input modality affect collaboration?[12]

Lab-based within-subject experiment
3 interfaces (non-interdependent)
3 conditions: different input strategies
10 groups, 3/group

Activity:

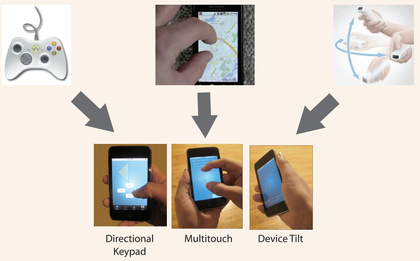
Shared tangram problem
- 7 pieces, 3 players

Activity selected because it requires two types of movement likely to be used in shared displays:
- Lateral/Vertical translation
- Rotation



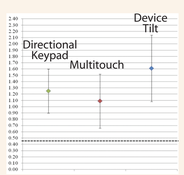
Conditions:

3 different input modalities:

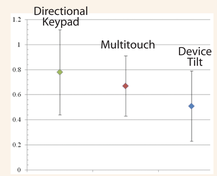


Findings:

No significant differences in collaboration measures



Participation Inequity (within-group SD of pieces placed) (95% CI)



Conversation Inequity (within-group SD of on-task remarks) (95% CI)

Number of remarks (per minute) coded as collaborative

	Directional Keypad		Multitouch		Device Tilt	
	AVG	SD	AVG	SD	AVG	SD
No acquaintanceship	1.48	1.15	1.34	0.91	1.48	0.94
Some acquaintanceship	1.67	1.04	1.49	0.83	1.18	0.80

Implications:

Perhaps input "friction" not responsible for higher participation equity in high IO condition (first study at left)
Perception of privacy should be investigated
Perception of O-UI (as "workspace" versus "control conduit") should be investigated

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