Virtual Agents

Low-Fi Prototypes Report

HCI Capstone 2016

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Executive Summary

During the low-fidelity prototype phase, we worked to apply what we had learned from research in practical ways that may aid in transcending the gap between virtual agents and physical interactions. In particular, we focused on our knowledge of sensing and actuation technologies. Additionally, we took into consideration the constraints of the task itself. Thus, we aimed to propose and test solutions that cultivated learning, collaboration, curiosity, and 3D building.

We brainstormed first individually, and then discussed our ideas as a team. Our ideas focused mainly on the physical environment and activities that could be performed by a virtual agent, realistically, with children. Working broad to narrow, we categorized our many ideas into several main categories: actuation, visualization, and sensing. From our large list, we discussed the pros and cons of each idea in order to narrow down to three representative ideas. We drafted storyboards of these three ideas to extract further detail and guide prototyping.

Our low-fidelity prototypes focused more on the physical interactions and gameplay of each idea, rather than the intricacies of the virtual agent as a character. We planned two different scenarios to represent the prototypes- Digital Prototypes and Beepboop. In these we had different ways of the virtual agent interacting with users- purely screen based, through a touch-table activity, and through a proxy named Beepboop. Overall we ran three trials that tested each scenario. Two trials included only single participants and one trial involved two participants. We recorded each trial, and conducted a brief survey and questionnaire with each participant at the end of all three scenarios. Due to time constraints and accessibility, we tested on college-age adults rather than children. Using feedback, we gained insight on levels of engagement, perceived agency, and curiosity.

The feedback from our testing, as well as our own brainstorming sessions, revealed the necessity of designing both an engaging activity as well as a compelling context and purpose for a virtual agent. In our testing, users found the virtual agent to be more of a parent/teacher instead of a peer. Using a more physical mode of interaction, like a proxy capable of tangibly manipulating objects, felt more collaborative to users. We hope to refine our prototype to include these considerations. Going forward we also recognize the need to adjust and pivot some of our ideas to reflect relevant technologies and capabilities.

Prior Research

Research prior to the low-fidelity prototyping phase emphasized current technologies and feasibility. A thorough literature review helped us to categorize and analyze different approaches to actuation, visualization, and sensing. Furthermore, interviews with several field experts exposed additional approaches and constraints. Key was understanding the intricacy of replicating human manipulation of an object, as well as the potential of a 2D activity and gamespace.

Prior to brainstorming, we conducted a task analysis of video data collected by the SCIPR project. We were able to observe how children create and collaborate in open-ended settings of play. We observed how certain personas emerged throughout different groups of children, and how participants can encourage curiosity. We found this insight to be incredibly valuable as it pertains to the role of virtual agents. That is, we noted the ability of a virtual agent to affect the physical world by communicating and drawing the attention of human participants.

Our research extended into the low-fidelity phase as well. We conducted an additional expert interview with Chris Harrison of the Future Interfaces Group at Carnegie Mellon University.

Expert Interview

We augmented our past research by interviewing Chris Harrison, the head of the Future Interfaces Group at Carnegie Mellon University. We used this time both as a brainstorming resource, as well as a way to explore the pros and cons of some of our proposed approaches.

Takeaways:

1. Focus on the specific task that we'll be designing and how to innovate on it. The technology can't function correctly without solidified task.
2. Need to consider how technology constricts the viability of tabletop activities and vice versa.
3. Because of technological constraints, even the simplest of our ideas will be difficult to realize fully.

Interview notes elaborated in appendix.

Design Considerations

Early work with the SCIPR team and research helped define high-level design goals for our project. Throughout ideation and prototyping, we aimed to satisfy the following:

1. *Incorporate 3D building* in a way that appears organic and equally engaging.
2. *Promote curiosity* in children through interactions with the virtual agent and the gamespace.

3. *Cultivate collaboration* and future exploration in players.
4. *Establish agency* so that the virtual agent is able to effectively collaborate and communicate with players.
5. *Incorporate sensing* so that the virtual agent may inspire actions in the physical world beyond just direct manipulation.

Ideation

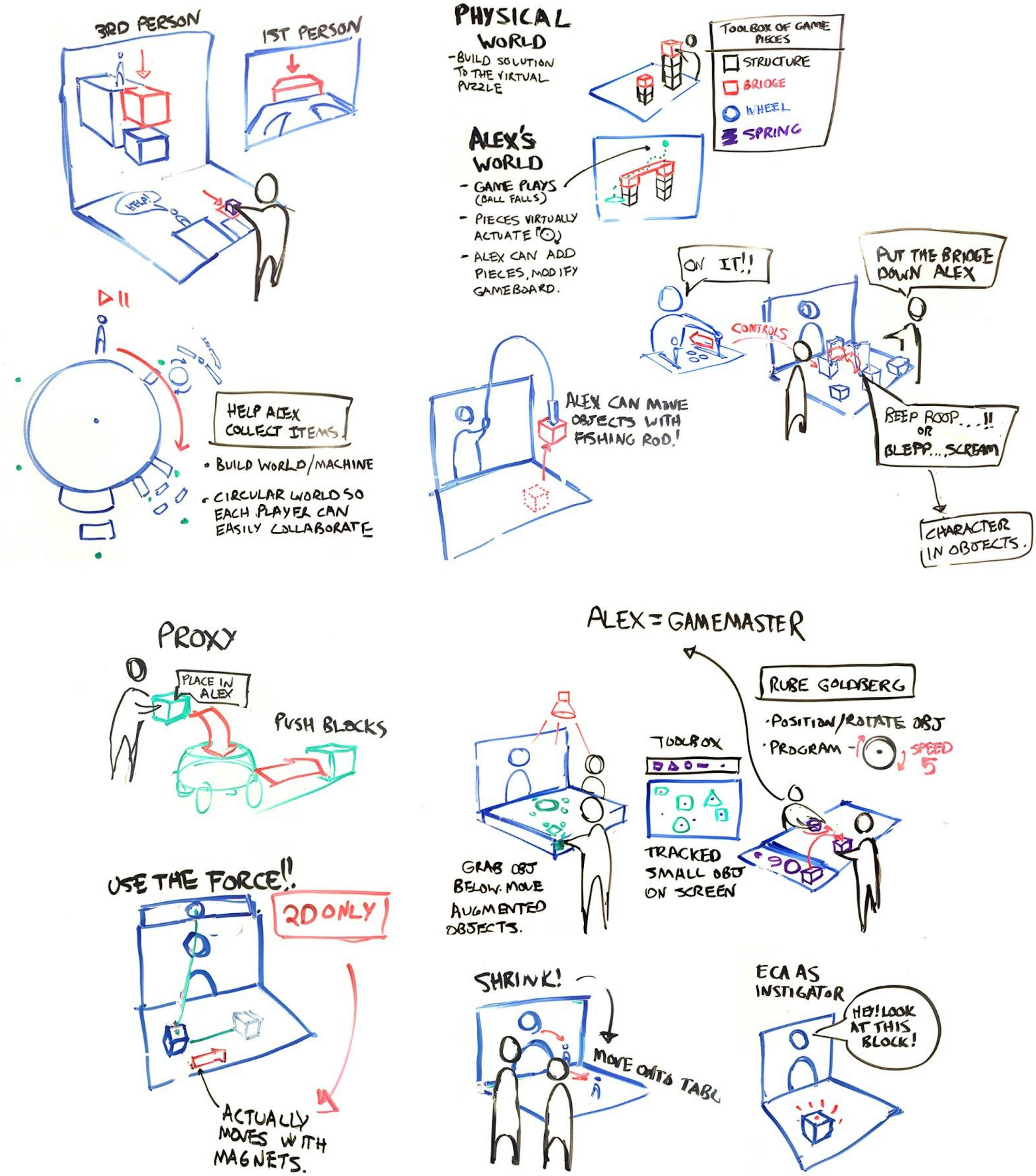
We ideated by first brainstorming individually. Each team member produced different scenarios that either focused on actuation, agency, sensing, or visualization. As a team, we then discussed our ideas and continued to elaborate on ideas presented. We used sketching as a technique to roughly visualize our concepts.

A total of 10 unique concepts/scenarios were produced as part of the initial ideation stage. We worked as a team and with our client to classify ideas into useful groupings: actuation, visualization, and sensing. Recognizing that our final solution should take into account all of these categories, sharpening our focus made it easier to produce testable prototypes later on.

As a team, we looked to our 10 concepts to identify those that would be most useful for testing. Based on client feedback, technical feasibility, and relation to design constraints, we narrowed our focus. Ultimately, we selected three concepts to pursue:

1. Using a proxy
2. ECA as operator of actuated objects
3. Affecting the virtual world with a tangible toolkit

We used storyboards to develop these three concepts more in depth. Based on the storyboards, we designed low-fidelity scenarios for user testing.

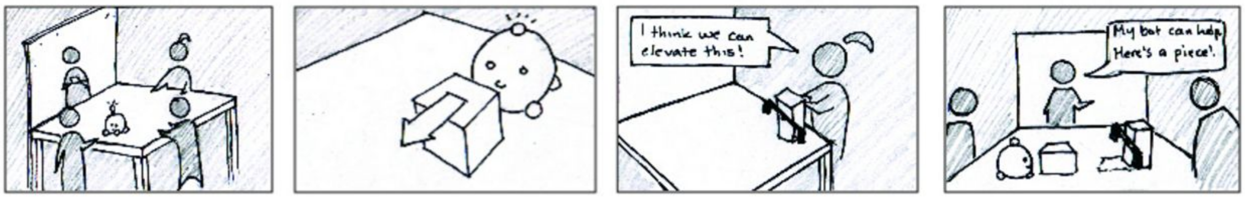

3RD PERSON
1ST PERSON
HELP!
PHYSICAL WORLD
-BUILD SOLUTION TO THE VIRTUAL PUZZLE
TOOLBOX OF GAME PIECES
STRUCTURE
BRIDGE
WHEEL
SPRING
ALEX'S WORLD
- GAME PLAYS (BALL FALLS)
- PIECES VIRTUALLY ACTUATE
- ALEX CAN ADD PIECES, MODIFY GAMEBOARD.
ON IT!!
PUT THE BRIDGE DOWN ALEX
CONTROLS
HELP ALEX COLLECT ITEMS!
• BUILD WORLD/MACHINE
• CIRCULAR WORLD SO EACH PLAYER CAN EASILY COLLABORATE
ALEX CAN MOVE OBJECTS WITH FISHING ROD!
BEEP BOOP...!! OR BLEPP... SCREAM
CHARACTER IN OBJECTS.
PROXY
PLACE IN ALEX
PUSH BLOCKS
ALEX = GAMEMASTER
RUBE GOLDBERG
·POSITION/ROTATE OBJ
·PROGRAM
SPEED 5
TOOLBOX
TRACKED SMALL OBJ ON SCREEN
GRAB OBJ BELOW. MOVE AUGMENTED OBJECTS.
USE THE FORCE!!
2D ONLY
ACTUALLY MOVES WITH MAGNETS.
SHRINK!
MOVE ONTO TABL
ECA AS INSTIGATOR
HEY! LOOK AT THIS BLOCK!

ALEX AS
BUILD A RUBE GOLDMACHINE
ALEX TIMES PARTS OF IT THAT CAN MOVE. CREATES CHALLENGE BUT ALSO USEFUL ACTUATION.
Alex turns the thing!
RUBE GOLDBERG
ALEX AS QUIET BUILDER (doesn't often initiate)
w/ cool simple machines
They began building
Jim notices what ALEX is building and asks
ALEX Explores a bunch of machines
OR
All players meet
Placed onto box kids can now build from
Here are your pieces
Objective: ALEX the VA wants to get to STAR
Kid places object on table to create digital version
pressing the object places a block in digital land
PRESS
HUH...
table simulates trajectory of ALEX
Kid adds a spring!
What about this one
blegh
POINT A → POINT B → Point X
POOP
reel
sketch
Suggest diff game piece?
Can draw a line
Curiosity HIGH
Adv. Engaging Science Learning
no need to worry about construction
shoddy build quality
Collaborative
EASY to sense GAME STATE
Dis. Difficult for Alex to participate
No 3D building
① CURIOSITY
② ALEX AGENCY
③ COLLAB/SOCIAL
④ 3D Building?
⑤ sensing capability
PUSH OBJ. AROUND
MY FRIEND WILL HELP
LVL 1
GRAVITY GOES OUT!
CONNECT DOTS
GO!
NATURAL BEHAVIOR/INTERACTIONS x ALEX's ROLE
· Suggesting type of "thing" to build
"Do you want to build a chain reaction?"
"How about this piece?"
Suggest
· explain mechanism
Alex experimenting on screen (kid to
· stack/attach objects w/ rubberbands
· always have objects in hand
hold objects in hand to observe or have in general table space
observe
· build w/o goal
"What are you building with the lever?"
"Here are some cool things levers can do"
INQUIRE
- explain concept with objects
"can cut hole in here and slide down here"
- does not ever build only speaks/suggests
gives objects to a player under double layer table
"What about this piece?"
under table shelf to pass objects
glow
ALEX'S DRAWER to try things
- disengaged when ignored
- suggest new ways of building
"that might work well. Try building it!"
"Here! Lemme try that out for you! Can you draw it for me here?"
know area free on table to draw simulation
Encourage + Collaborate
- stacks objects
- "hmm how does this work?"
- builds what's needed by other players
- talks to self / builds "we can elevate this" "Lemme see..."
- never Finishes thoughts/sentences.
- looks in box on side for more materials
- discover/wonder what new objects are
- explore potential of objects
- only verbally states ideas → encourage drawing / speaking / building
- watches/Listens to others intently
- holds up pieces to display to others
- touch objects to demonstrate
- pick piece try. Return
Kids: build things
What can Alex do?
physical prototype + digital input
test simulation
Final Machine
Alex: Point something out (why...?)
Design ONE "right" answer?
Exploration... How? No sense of right/wrong
2.50
ALEX POINTS THINGS OUT
why/what
randomly suggests unused piece
· make machine better (suggestions)
· prompting unegaged, social engagement
2D: verbal/notetaking
3D: just building
simulation
indicators
3D BUILDING
· HOW TO GET ALEX'S PHYSICS SIM TO MATCH WHAT WOULD ACTUALLY HAPPEN.
YOU DID IT!
PHYSICAL
DIGITAL MODEL
IF PHYSICAL BUILDING, ALEX'S SIMULATION WILL ALWAYS BE INCONSISTENT. + occlusion issues
THUS ALEX WILL NOT BE ABLE TO DIRECT KIDS TOWARDS "RIGHT ANSWER"
ALL SUGGESTION FEEL RANDOM?
EVEN IF ALEX KNOWS THE RIGHT ANSWER, WHAT WOULD ALEX DO BEYOND GIVING ANSWERS?

Prototyping

Prototype Concept 1 [BeepBoop]

Using a Proxy



ALEX has a pet Bot. Bot can push objects around Tina suggests a new idea. ALEX helps through his proxy bot

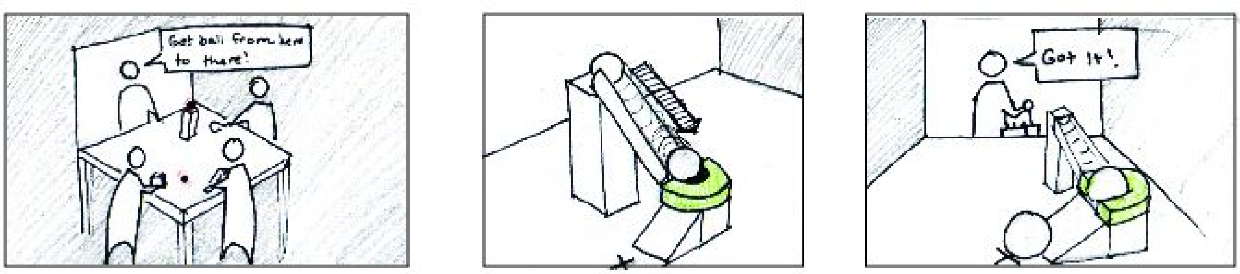
With this concept, the ECA interacts with the physical world through a proxy ‘pet’. The pet is able to move about the table, pushing pieces in accord with the ECA’s intent. In this sense, the proxy is able to help build as well as make suggestions as to courses of action in the physical space.

Benefits: this approach simplifies the ability of the ECA to interact with physical objects as compared to a more realistic, humanistic motion. It also may inspire collaboration.

Barriers: Limited 3D capabilities beyond pushing pieces.

Prototype concept 2

Actuated Objects



ALEX can initiate new activities Kids at the table build a ramp with a part that only ALEX can control. ALEX turns the green piece allowing the ball to roll to final destination

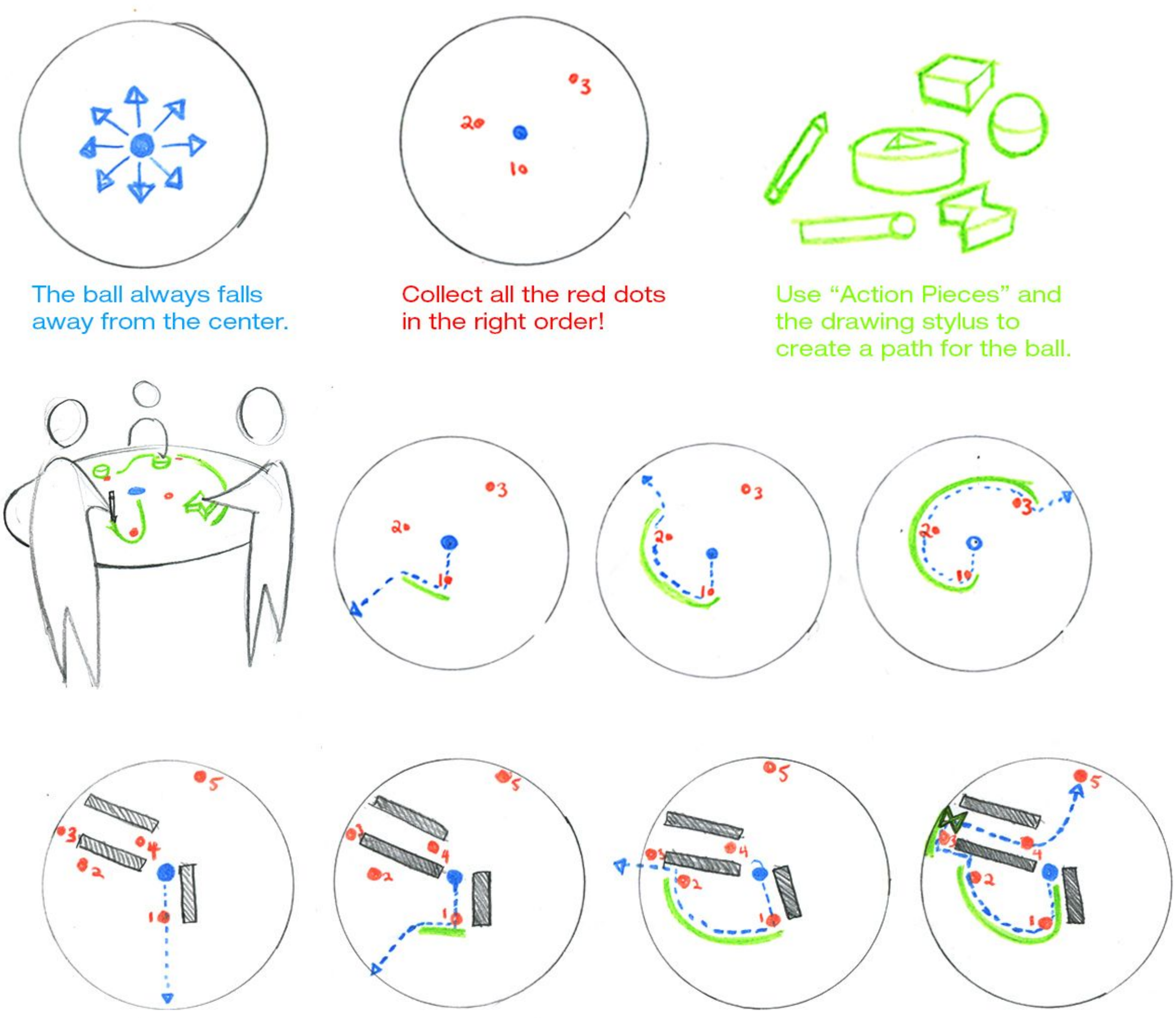
With this approach, the ECA is able to control some aspect of the gamespace that the players cannot. In a Rube Goldberg scenario, the ECA might have the ability to turn a certain piece on the table in order to complete some activity. The players would have to interact with the ECA to describe their intent, and get the ECA to help.

Benefits: Could support 3D building. Inspires curiosity and collaboration in ways similar to that demonstrated in task analysis videos.

Barriers: Low sensing capabilities. Alex’s agency has low impact beyond the ability to affect certain pieces on a table.

Prototype concept 3 [Digital Physics]

Affecting the Virtual World with a Tangible Toolbox



This approach combines the physical and virtual world to create a mixed reality experience. Players are given a ‘toolbox’ of different objects. Players are instructed to help the ECA (visualized on a screen) achieve some goal by placing the objects on the table surface in front of them. As they place the objects, they can view how the ECA's world is affected in the virtual world by looking at the screen for feedback.

Benefits: Easy to visualize effects on screen. Could incorporate elements of physics and scientific exploration.

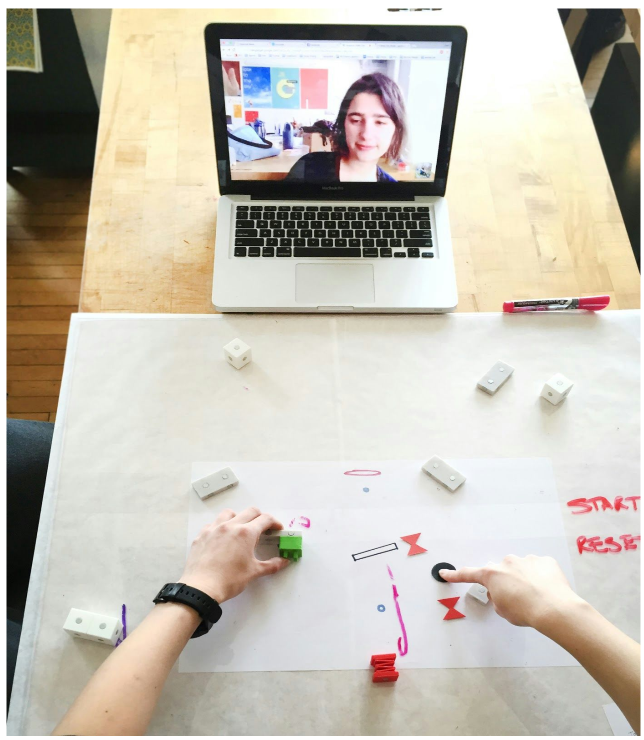
Barriers: Difficult for the ECA to participate. Limited use of 3D building. Reverses the core of the project, as players are now able to use the physical space to affect the ECA's virtual world.

Testing: Methods

All participants were given a short survey after each activity and were interviewed at the end of the session. The survey included questions that measured perceived levels of agency, how collaborative the activity felt, curiosity levels and engagement. The interviews were unstructured and were done in a group when there was more than one participant in a session.

Digital Physics (test 1)

1 User (creative writing major) + ECA on laptop screen and as character inside ball being simulated.



The ECA was re-enacted on a laptop screen through Google Hangouts. The ECA participated also as the person inside the ball that moved through the physics simulation. Re-enactment of ball movement was shown on the laptop screen. Ben acted as physics simulator.

ECA's Interactions:

- Asking user to draw what they were thinking
- Placing object on table so ECA could "see" what they were talking about
- Redrawing what happened in a previous simulation
- Suggesting pieces to use
- Unrelated comments and pointing to objects arbitrarily ("spring looks fun")

Findings:

- Alex has many opportunities to help direct a player, but lacked character.
- This game would be more fun if they had someone else to play with.

- Peaked the most curiosity compared to BeepBoop test 1.
- Alex was the physic simulation object (the ball that actually falls), but having him play would have been better.
- Player, who was not interested in physics/engineering was not excited about this game.
- Connection between Alex and Beep Boop was clear from their common language
- Beep Boop was seen to be picky

BeepBoop (test 1)

1 User (creative writing major) + ECA on laptop screen + "BeepBoop Bot"

Su simulated BeepBoop's actions and Sam acted as ECA through laptop screen. Activity begins with ECA asking if the player wants to build an object.

ECA's Interactions:

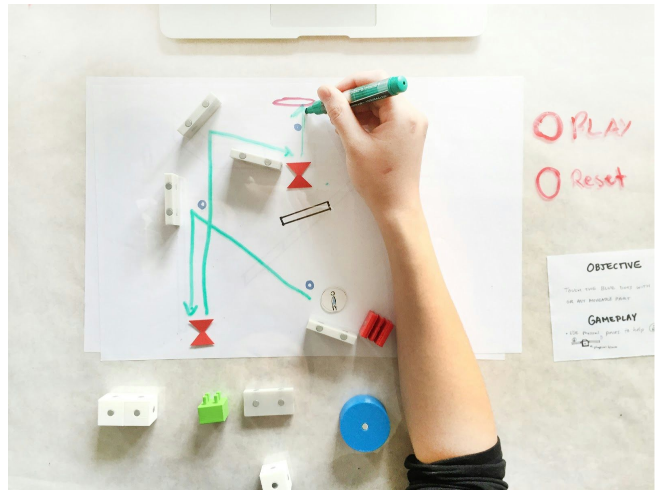
- Suggesting to add more (build also a tree! Adding columns)
- Show objects through screen
- Building on the screen
- Suggest activity and show images of prompts (build giraffe vs alligator?) - pops up on table once chosen.
- Speak with BeepBoop to point at objects
- Question BeepBoop's 'erratic behavior'

Findings:

- Proxy having erratic behavior allows for both ECA and player to interact on the same level of understanding (confused by Proxy behavior and trying to parse meaning)
- The proxy "BeepBoop" acted as a great middleman for ECA to interact with. This made ECA seem more real because he had an effect on something in the physical world.
- Proxy lowered seriousness and pressure of activity.
- User is not inspired by the building that occurs on the screen unless prompted (this might be an issue with the prompt given. The prompt should emphasize collaborating with the ECA to build something)
- User felt like they were playing with ECA and Proxy and they were not lonely.
- Proxy having a pushy behavior engaged the user to a certain extent.
- Working with an open-ended task felt more collaborative and creative
- Beep Boop's suggestions sometimes curbed creativity instead of triggering it

Digital Physics (test 2)

2 Users (programmer and ECE) + ECA on laptop screen



The ECA is no longer in the ball but only on laptop screen, played by Ben. Sam acted as physics simulator.

ECA's Interactions:

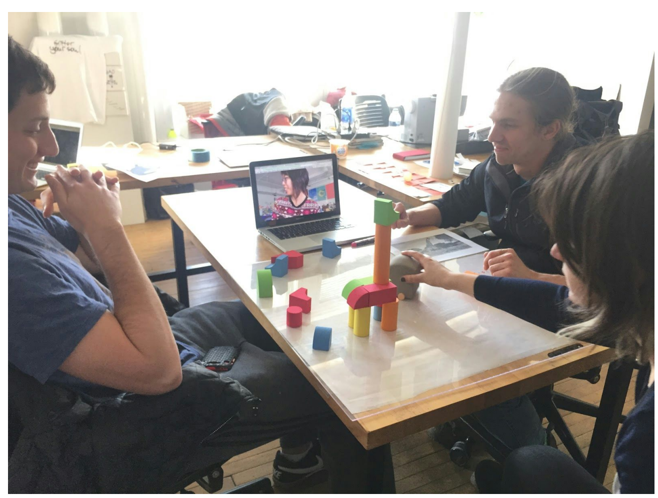
- Same as previous trial, but Alex was not in the ball.
- Alex explained what certain pieces did when subjects were curious about them

Findings:

- "It would be better if Alex was involved with what we were making".
- Player suggested that it would be cool if there was a beep-boop like character in the digital game. They could play with him instead of having Alex be a "teacher".
- Players were curious by the unknown pieces and how they could incorporate them into their solution. They were also curious what would happen when they pressed play.
- Players thought Alex was more involved in digital physics.
- Alex felt like a cheerleader.
- In seemingly constrained solutions, the players came up with radical solutions.

BeepBoop (test 2)

2 User (programmer and ECE) + ECA on laptop screen + "BeepBoop Robot"



Su simulated BeepBoop's actions and Sam acted as ECA through laptop screen.

ECA's Interactions:

- building objects and asking players what they thought
- otherwise, same as test 1

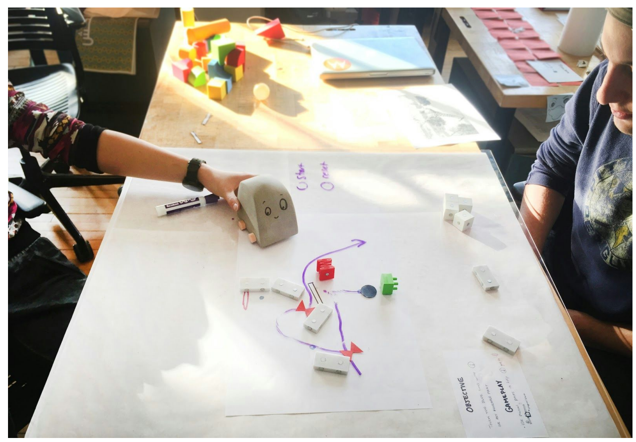
Findings:

- In a collaborative environment, it is difficult to direct attention in a meaningful way. Who is the proxy trying to get the attention of?

- The activity needs to facilitate more interaction between players and be more open ended: “This activity was too defined. I felt like I couldn’t really explore while building.”
- There was little reason to engage with ECA because the suggestions given were small and not goal driven.
- Proxy acted well as comic relief
- ECA building on screen amplified the fact that ECA was trapped behind screen because players couldn’t build off of ECA or with ECA.
- Users are willing to bring what they are building in front of laptop screen to show ECA what they were building.
- Users were absorbed with their activity and rarely looked at Alex’s screen
- Participants wanted the activity to be more goal-oriented

Digital Physics + BeepBoop (test 1)

1 User + ECA as proxy on tabletop



Alex embodied in the physical robot instead of represented on screen. Sam acted as the physics simulator.

ECA’s Interactions:

- Actually plays with the other player by placing objects just like any other player.
- Draws idea/path by driving and leaving a trail behind him
- Points at things physically and digitally highlight for clarity.
- Moves around with “character” and animation that BeepBoop had

Findings:

- Player really liked the game and playing with Alex.
- “Alex helped me get farther than I could have gotten myself”, “I felt like I had a friend to play the game with”, and “Made it so I wasn’t quiet and made me talk”.
- The player wished that he was even more friendly and less like a parent.
- Player felt like Alex would nudge him too soon and not let him struggle.
- The player was the most curious when confronted with a new level.

Testing: Results

Takeaways

Overall, we found that BeepBoop brought interactions with an agent to the table and was overall really fun, likable and capable of invoking curiosity. With that said, he lacked a distinct function within the playspace. Because Alex had a lot of information within the digital physics game, Alex was able to interact meaningfully with the players but was more of a “teacher/parent” rather than a “companion”. We will look into solutions that combine what we learned about likability and tangibility from BeepBoop with the functionality and cognitive scaffolding that Alex could provide in the digital physics game.

Next Steps

Prototype simple machines in 3D and test a physics game in a 3D environment

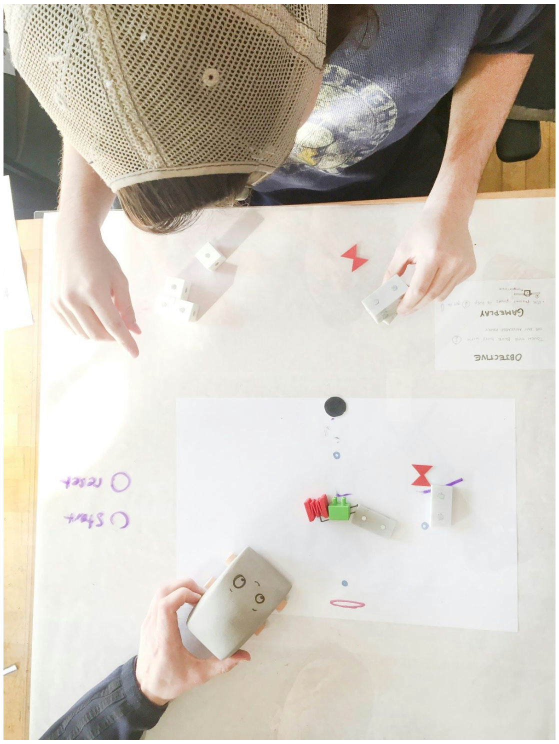
Through testing, we found that the digital physics activity was more engaging and inspired more curiosity and experimentation from players. Curiosity came from not knowing the behavior of certain objects and not immediately knowing the correct solution given these mysterious objects.

The digital physics activity allowed the ECA more options to interact with the user through drawing on the same playing surface, displaying previous outcomes, and being able to sense objects on the table. In our next stage of prototyping we will simulate a similar activity instead with simple machines such as lever, pulley, wheel and axle, inclined plane, screw, and wedge. The activity will involve obstacles and getting an object from Point A to Point B with verbal hypothesizing from players. This will incorporate a top priority for clients which is physical play.

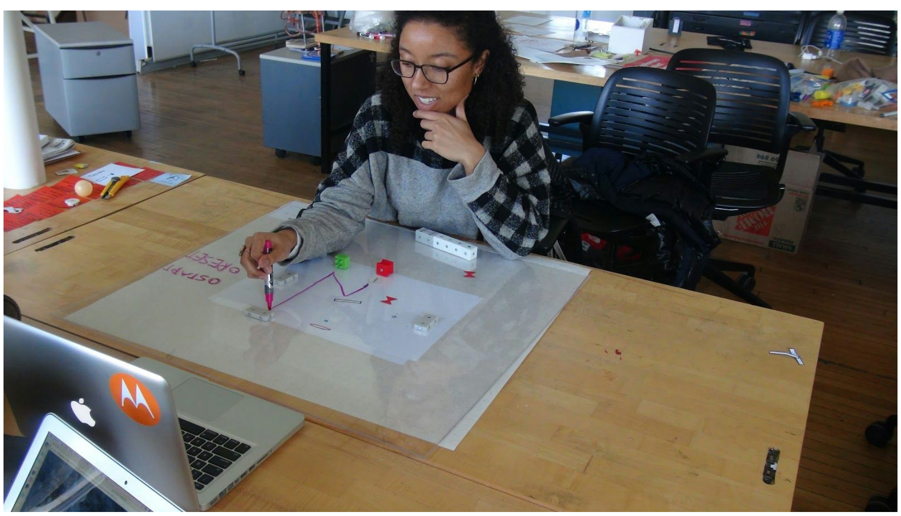
Prototype ALEX as a small tabletop robot.

We found that players rarely looked at Alex on the screen as they were focused on the game or BeebBoop. What if Alex was BeebBoop? If we want to retain his humanoid form, what if he drove a car around pushing objects? Either way, it would place Alex directly in the physical game space while retaining all of his digital knowledge and capabilities.

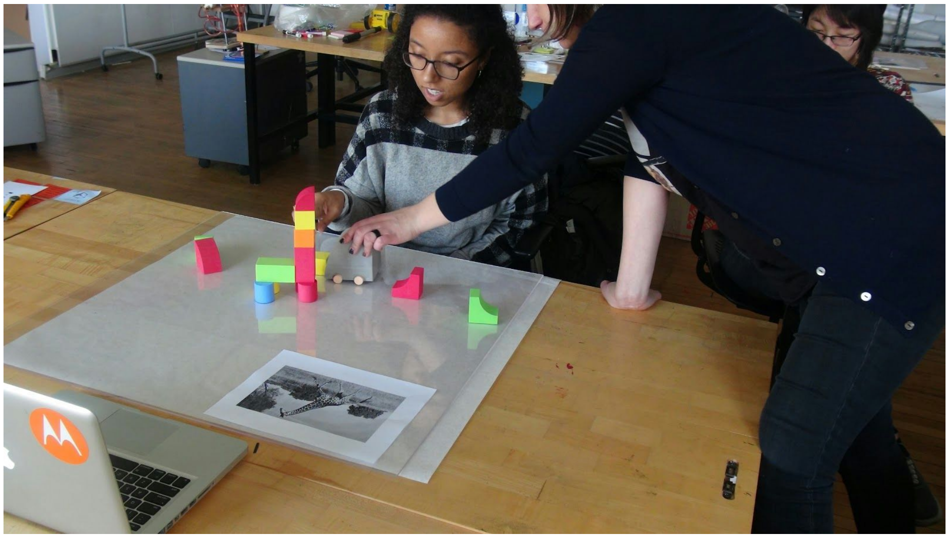
Appendix

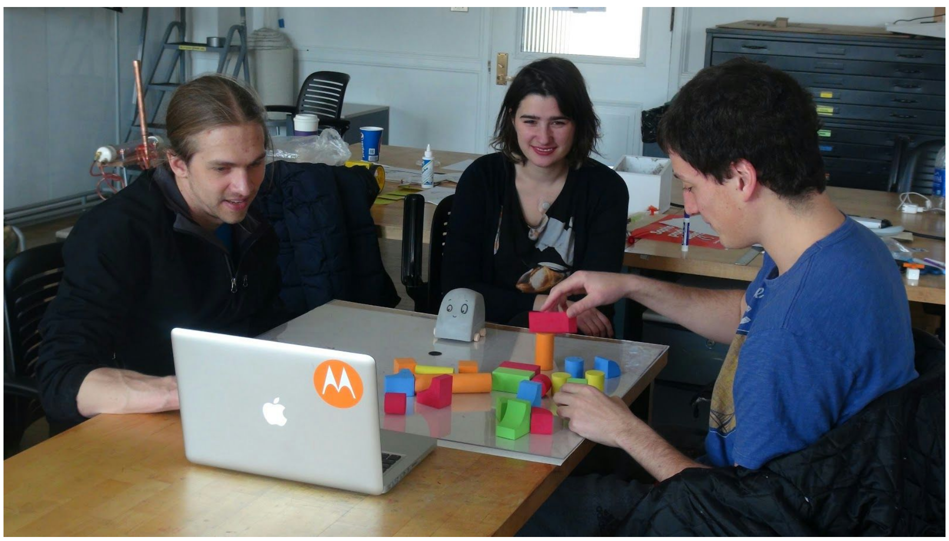


Digital Physics Activities and Pieces



BeepBoop Activities and Pieces





Chris Harrison Interview Notes

Feedback on Ideas

[1] Dropping into digital space (Tiggly Idea)
Easiest to implement and most practical
Use multiple touch screen or optical table (make your own)
Capacitive Screen

[2] Physically building game pieces (Cubelet Idea
Capacitive tangibles (tangibles is a beaten to death concept and explored field)
Maggets (magnetic actuated table) - AVOID at all costs. Incredibly dangerous. terrible to build
AR tag on blocks with overhead camera (use color = no need for AR tags)

[3] Proxy
Not easy… nothing off of the shelf
2D push car is harder than you think

Difficulties

- mechanical robots push through anything. Little spatial awareness.
- tracking physical ball will be difficult
- sound of tiny robots is distracting and breaks experience. robotic embodiment not believable with the noises. More forgivable if robotic parts instead conveyed as silly robot friend of ALEX.

Idea suggestions

- Shelf under table where objects are moved so projected hands of ALEX are in the same plane as kid's hands
- tangible single parts
- innovate on task (make paper plane? blow leaf across water?)
- whiteboard wall 3D task + magnets better for tasks with gravity (zhen doesn't like)
- ALEX pushes objects out as suggestive pieces to use from his own compartment?
- Ephemeral way to interact (fan to blow leaf)
- Alex sneezing makes table shake and knocks over some blocks

Suggestions for moving forward

- pick task that works well with the medium
- **innovate on the task** (make paper plane? blowing a leaf across water?)
- focusing energy on recreation of existing tech or novelty in task?
- FOCUS on what is SIMPLE and DOABLE
- can rent 27" touchscreen display from Chris when at that stage

Client comments post-meeting

- focus instead on knowing what is happening on the table and sensing. Actuation not as important. Alex implements social strategy
- Gravity and Elasticity. Simple Machines