Kinetic City Empower

Research Report

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American Association for the Advancement of Science

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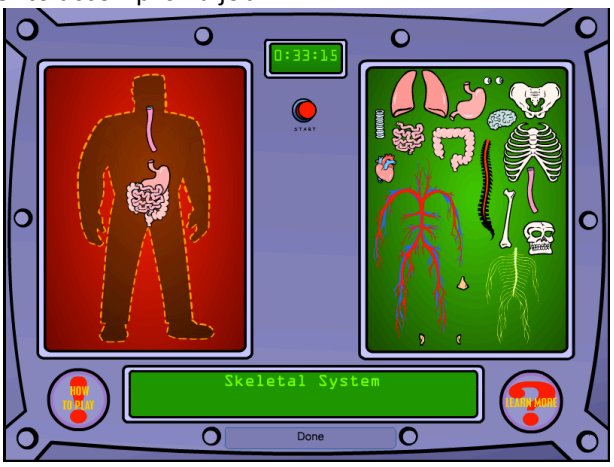
Introduction

The overall purpose of the Kinetic City (KC) Empower project was to examine how informal science activities can be made accessible for students with disabilities. The premise of this project was that all students, including those with disabilities, are interested in and capable of engaging in science learning experiences, if these experiences are accessible to them. Drawing on resources from Kinetic City, a large collection of science experiments, games, and projects developed by the American Association for the Advancement of Science (AAAS), the project researched and adapted five afterschool science activities guided by universal design for learning principles.

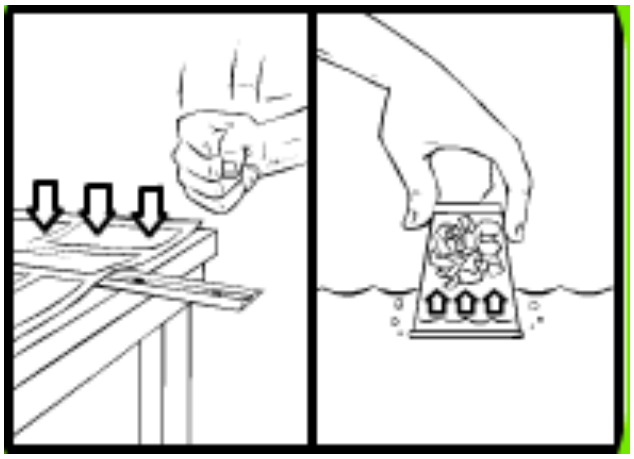
The focus in this project was on five Kinetic City activities that were chosen because they represented different genres of activities: a computer-based activity, a kinesthetic activity, a set of two hands-on activities, a writing activity, and a drawing activity. Specifically, KC Empower investigated the following five activities.

All Systems Are Go is a Flash-based game in which players have to assemble the internal organs for a character, Arnold Rutabega, who has lost all his organs. The original game presents players with a collection of organs, which they have to drag and drop onto the outline of Arnold's body to assemble four major systems of the human body: the circulatory/respiratory, skeletal, digestive, and nervous systems. A Learn More button brings up a text essay on the major systems of the human body, describes the organs and other parts in each system, and explains how they work together to accomplish a job.

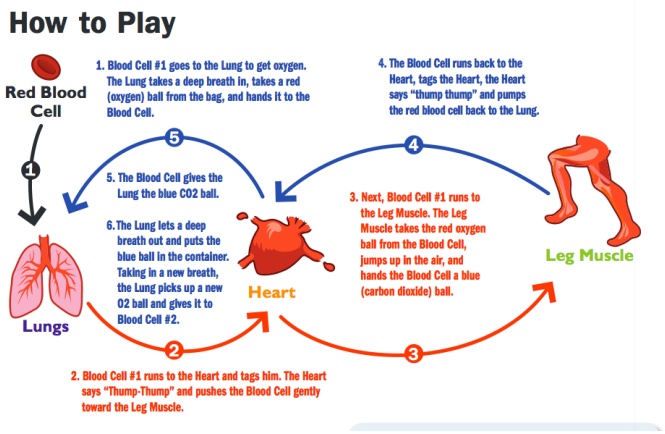


Dunk and Flip is a set of two hands-on activities that illustrate that air has mass and takes up space. In the dunk activity a paper towel is pushed into the bottom of a paper cup, and this cup is submerged, face down, in a tub of water. When the cup is removed from the water, students notice that the paper towel stayed dry. This is because air was already in the cup, taking up space and keeping the water out of the cup. In the flip activity, a yardstick is placed on a table sticking out about halfway from the edge. The portion of the yardstick that is on the table is covered with a large sheet of newspaper, spread out flat. Students are asked to push down on the yardstick and observe what happens. They observe that the yardstick is very hard to push up. They are then asked to repeat this activity, crumpling up the newspaper and putting it on the yardstick. Students discover that the newspaper now flies up in the air very easily when they

push on the yardstick. This activity demonstrates that air is pushing down on everything. The flat newspaper has a much larger surface area than the crumpled up newspaper and therefore more air mass is pushing on it.



Respiration Stations is a kinesthetic activity that simulates the circulatory/respiratory system. Players assume the roles of the heart, lung, leg muscle, and one or more red blood cells. The red blood cell has to move from the lung to the heart to the leg muscle to deliver an oxygen molecule (represented by a red ball), and pick up a carbon dioxide molecule (represented by a blue ball), to transport it back to the heart and the lung, where it exchanges the carbon dioxide molecule (blue ball) for an oxygen molecule (red ball). The red blood cell then repeats the above steps. Students learn how the different parts of the body work together to do an important job.



Where the Weird Things Are is a writing activity in which students are asked to describe the environments in which creatures with various features might live. Students are shown pictures of six fantasy creatures and are asked to make up a story about them that describes where the creatures live and how their strange features help them survive there.

Blueprint for a Beast is a drawing activity which engages students in thinking about how the features of a creature relate to the environment it lives in. In this activity, students are asked to draw a creature that can live in one of these unusual environments: inside a volcano; 35,000 feet above the ground (where airplanes fly); on an iceberg in the middle of the ocean; under the hood of a car; or in your nose. In designing their creature, students are tasked to think about how it moves, drinks and eats, and protects itself from any dangers its environment presents.

The KC Empower project was carried out in three major phases. In Phase 1, we conducted research with students with disabilities to examine what access barriers students experience as they engage with the original five Kinetic City activities. In Phase 2, the activities were revised based on information gathered through the initial research and input from a national advisory board. Table 1 (pages 5 and 6, below) summarizes the revisions that were made in the activities. In Phase 3, we tested the adapted activities to examine if the changes were successful in improving the accessibility of the activities for students with a range of different disabilities. The focus in this project was on students in grades 3–12 with physical, sensory, cognitive, and developmental disabilities. This report summarizes the research that was conducted as part of this project.

Methods

The purpose of the research was to obtain information about the accessibility of the five Kinetic City activities under investigation to guide their continual improvement. The research was designed to collect information about the access barriers that the original activities posed to students with a variety of disabilities, and to assess how the adaptions that were made to the

activities affected their accessibility for these students. Our observations were guided by the framework for inclusion in informal science education (Reich, Rich, Rubin, & Steiner, 2010), and focused on the following questions.

1. Physical Interaction with the Activity

- Are the activities designed in such a way that individuals with diverse abilities can interact with them?
- Is the information in the activity conveyed in a variety of formats so that individuals with diverse abilities can perceive it?
- Can individuals with diverse abilities manipulate or cause things to happen within the activity?

2. Cognitive Engagement with the Activity

- Is the information conveyed using a range of media to allow individuals with diverse abilities to engage with the materials?
- Do the materials take into account individuals with a range of learning and cognitive skills?
- Do the materials take into account individuals with ranges of experiences and varying sets of background knowledge?

3. Social Interaction

- Are the activities set up to comfortably and safely foster and facilitate encounters and engagement among individuals with diverse abilities?
- Are the activities designed to provide meaningful reasons to foster and facilitate interactions and discussions among individuals with diverse abilities?

Participants

The participants in the research were students with a range of disabilities, and their teachers, from two schools in Washington, DC. The first group consisted of 14 students with learning disabilities (including dyslexia, attention deficit disorder, attention deficit hyperactivity disorder, and anxiety) from a small private school. These students ranged in age from 8 to 12 years and were predominantly male. The second group consisted of about 35 students with multiple disabilities (i.e., cognitive, physical, speech, visual, learning, and developmental disabilities and other health impairments) who attended a special education public school. The students in this group ranged in age from 10 to 22 years and about half of them were male and half were female. Few of the students were able to read or write, and several were nonverbal. Most students received one-on-one support from a teacher or aide.

Table 1: Revisions in the Five Kinetic City Activities

All Systems Are Go

- Made the game keyboard accessible, in addition to mouse accessible.
    - Making all possible selections into buttons that can be accessed by the tab button and selected with the spacebar or enter key.
    - Shift Tab should tab through selections backwards.
    - Game should start with cursor at top; spacebar should trigger "Start Game."
    - Add a visual indication of keyboard focus.
    - Keyboard commands should function on all screens, including the Play Screen, the How To Play screen, and the Learn More screen.
    - For gameplay, put keyboard focus on any body part, beginning with top one; then use left, right, up, and down arrow keys. Keyboard focus should highlight part and play audio.
    - When highlighted, enter key or space bar selects.

- Added audio for all buttons and selections; added narration for How to Play and Learn More.

- Gave the organs in the game "object permanence"—for example, when an organ was dragged from one screen to another, there was never a reoccurrence of that organ in the screen from which it was dragged.

Respiration Stations

- The balls representing carbon dioxide and oxygen molecules were replaced, so that the balls representing the carbon dioxide molecules were slightly larger and had a different texture than did the balls representing the oxygen molecules.

- Students who played the roles of the heart, lung, and leg muscle were asked to make sounds to represent their organ.

- In a variation of the game, two students were asked to represent the heart's two ventricles, so that one child pushed the red blood cell toward the leg muscle, and the other pushed the red blood cell back to the lungs.

Dunk and Flip

1. Dunk Activity

- The plastic tub and paper cup were replaced with a 2-liter soda bottle, cut in half to make a water tub (the bottom half of the bottle) and a cup (the upper half of the bottle). Food coloring was added to the water, so students could more easily differentiate water and air.

2. Flip Activity

AAAS developed two replacement activities.

- Students were given a long plastic tube with a volume of 45 liters and asked to blow it up like a balloon. They noticed that they made little progress even after several blows of air. They were then asked to lay the tube flat and blow toward it from a foot away. They notice that it quickly fills with air—the stream of air they blow into the tube entrains much more air from the room and carries it into the tube. The demonstration helps students visualize the fluid dynamics of a room full of air, as opposed to a room full of nothing.

- Students are asked to weigh air, using a standard 1-liter or 2-liter soda bottle fitted with a special cap that has a bicycle tire-style air valve. Students weigh the bottle on a scale and write down the result. Then they take the bottle off the scale, attach it to a bicycle pump, and add more air into it (ideally, to a pressure of about 50 psi). Then they weigh the bottle with the extra air and notice that it is significantly heavier.

Where the Weird Things Are

- The original activity had just black-and-white line art to show the creatures. For the revised activity, AAAS contracted with a company called Touch Graphics to recreate the artwork as a book of 3D raised images, with colors and textures.

- In addition, each creature was divided into parts, like "head," "body," and "tail," and each of these parts had a text description, i.e., "This creature has a long tail with a spike at the end." The descriptions are given in both letters and braille. Talking pens were programmed to read the descriptions out loud when a user holds the pen over a creature or a particular feature.

- When presenting the activity to students, they had access to an assortment of plastic animals, such as porcupines and walruses, and the facilitator engaged students in a discussion of how these real animals' features helps them survive in their environments.

- The title of the activity was changed to "Your Creature's Features."

Blueprint for a Beast

- In addition to being provided with a variety of art supplies and papers, students also had access to modeling clay and wiki sticks to enable them to create their creatures in 3D.

- The facilitator introduced the activity by reading *The Mixed-Up Chameleon* by Eric Carle, stopping to ask students about different characteristics described in the book and what each animal did with its adaptation.

- Students were asked to show and describe their creatures for the group.

- Students were given the option of taking their creatures home with them.

Procedure

The procedures for assessing the accessibility of the original activities and the adapted activities were the same. The students participated in groups with their teachers, either during afterschool hours or during learning center time. A facilitator from AAAS first introduced and demonstrated each activity, and then students had the opportunity to engage in the activity themselves in small groups or individually, with the help of their teacher or aide where needed. Given the size of the groups in the two schools, the activities were carried out in sequence with the students with learning disabilities. For students with multiple disabilities, workstations were set up for each of the five activities—similar to a science fair—and students circulated through these workstations individually or in small groups. Researchers observed students and teachers as they engaged in the activities, and conducted informal interviews with students and teachers whenever feasible. Observations and interviews were recorded through ethnographic notes. The researchers also collected samples of students' work.

Analysis

Ethnographic field notes and work samples were analyzed thematically, using the framework for inclusion in informal science education (Reich, Rich, Rubin, & Steiner, 2010) as a guide.

Findings

Overall, we found that virtually all students were able to participate in the activities, either independently or with the help of their teachers, and most, if not all, of the students appeared to be engaged with the activities. Below, we report findings for each of the five activities under investigation in turn.

1. All Systems Go

Students' and Teachers' Responses to the Original Activity

Physical Interaction with the Activity

• The drag-and-drop feature can be challenging, especially for students with fine motor coordination issues.
• The use of the Smart Board (using a tennis ball on a stick as the input device) made it easier for some students with physical disabilities to interact with the game.
• Teachers suggested providing a hands-on option of the game (in 3-D or 2-D).

Cognitive Engagement with the Activity

• Students gravitated to this activity and were very engaged.
• Students did not pay much attention to the clock.
• Some of the game mechanics were confusing for students (e.g., when they made a mistake, all the organs previously assembled went back to the right side of the screen while simultaneously being displayed on the left; when they finished one system, the body parts already assembled on the left side of the screen reappeared on the right).
• Students found it visually confusing that body systems were superimposed onto each other.
• Some of the students with learning disabilities did not like the sound of Arnold's voice.

• Some students with learning disabilities questioned the logic of Arnold talking while "being in surgery."
• Some students with learning disabilities wanted to see all the bones.
• Very few students explored background text.
• Teachers offered several suggestions for improving students' cognitive engagement with the activity:
    - Add labels and have computers read them.
    - Simplify what's on the screen (use separate screens for different systems).
    - Don't have organs reappear on the right side of the screen when students make a mistake.
    - Give feedback when students get it right.
    - Reinforce systems with songs (e.g., drumbeat to go with the heart).
    - Eliminate the time element.

Social Interaction

• The use of the Smart Board facilitated student collaboration.

Students' Responses to the Adapted Activity

Physical Interaction with the Activity

• Students with learning disabilities were able to interact with the adapted game more smoothly, without the frustration that the drag-and-drop feature had created.
• Students with learning disabilities liked the audio descriptions/labels for the organs. One student with a learning disability explored the audio labels for the organs.
• Students with learning disabilities suggested using voice control to select an organ (selecting it by saying its name).
• Students with learning disabilities suggested using the arrow keys (rather than the tab key and space bar) to move the organs.
• Some students with learning disabilities found the narrator's voice "annoying."
• One student with a learning disability indicated that he could not hear the audio narration very well.
• A student with fine motor issues used drag-and-drop to interact with the activity and struggled with it. He did not try interacting with the game using the tab key/space bar. His teachers suggested that a mouse would help him interact better with the game.

Cognitive Engagement with the Activity

• Students with learning disabilities did not get frustrated when they made a mistake in the adapted version, because the organs that they had already successfully placed did not disappear.
• Students with learning disabilities liked that the organs that they placed got removed from the screen on the right.
• One student with a learning disability played the game against time and was able to finish it in less than 2 minutes.
• Students with learning disabilities did not pay attention when the audio narration was played.
• One student with a learning disability used trial and error to place organs for the circulatory/respiratory systems, and the nervous system (toward the end of the game).

Social Interaction

• Playing the game on the Smart Board or with an overhead projector facilitated student collaboration.

Summary

The key changes that were made in the game (offering an alternative to the drag and drop feature for moving the organs, providing audio labels for the organs, changing the response that students got when they make a mistake, removing from the right side of the screen organs that have been placed) were successful for improving the physical accessibility of the game and students' cognitive engagement with it.

Further changes could be made to improve the quality of the audio narration and to provide alternative ways to convey the information it transmits. Currently, the activity is designed for a single player. Alternate versions could be developed to support social interaction among multiple players. Our observations that some students did not make use of the improved features also raise the question of how students and teachers will be made aware of the different options for interacting with the game, so they can make choices about what works best for them.

2. Dunk and Flip

Students' and Teachers' Responses to the Original Activities

Physical Interaction with the Activities

• Students with multiple disabilities did not engage in the activities hands-on.
• Students with learning disabilities were at first a little tentative to do the activities hands-on; they got more involved with the dunk experiment than with the flip experiment.
• Students with learning disabilities had some difficulty with replicating the dunk experiment exactly (some air escaped when they immersed the cups, so their paper towels got wet), which made them wonder why this happened.
• A teacher of students with multiple disabilities suggested giving students permission to manipulate things hands-on.

Cognitive Engagement with the Activities

• Few of the students with multiple disabilities were drawn to these activities on their own, but some of them got engaged when the facilitator demonstrated the activities.
• Students with learning disabilities, while intellectually engaged and curious, were at first a little tentative to do the activities hands-on. The students stayed in their seats to watch. They were somewhat more engaged in the dunk activity than in the flip activity.
• At least some of the students with learning disabilities had an understanding of the concepts of air taking up space.
• Students with learning disabilities were able to make predictions about what would happen to the paper towel when the cup was immersed in the water.
• Teachers of students with multiple disabilities offered several suggestions for improving students' cognitive engagement with the activities:

- Find a way to make air visible (e.g., use smoke).
- Give students an opportunity to feel the air as it escapes.

- Help students see the connection between the dunk and flip activities.
- Help students see the connection between the activities and their real life.

Social Interaction

• Demonstration of the activity by an adult increased students' engagement with it.
• Teachers of students with multiple disabilities suggested that it would be important for a teacher to demonstrate and facilitate the activities.

Students' Responses to the Adapted Activities

Physical Interaction with the Activities

• Students with learning disabilities were more likely to interact with the adapted versions of the activities in a hands-on manner (they wanted to feel the paper towel and the plastic tube).
• Students with learning disabilities liked the adapted version of the dunk activity more because they could see better what was going on.
• Students with multiple disabilities did not interact with the dunk activity hands-on.
• Three students with multiple disabilities were able to use the air pump and scale to measure and record the weight of air in the 2-liter bottle.
• One student with multiple disabilities, including fine motor control issues, had difficulty with putting the bottle with air on the scale. He also had difficulty reading the scale from a sitting position (the student used a wheelchair). The teacher assisted with reading the weight on the scale. The student also had difficulty with pushing down the pump to put more air into the bottle. The facilitator helped with the pumping.

Cognitive Engagement with the Activities

• Students with learning disabilities were more engaged in the adapted version of the dunk activity. Some students got out of their seats and moved closer to the demonstration to better observe what was happening. Students passed around the top to feel the paper towel.
• One student with multiple disabilities was able to offer air as an explanation for why the paper towel did not take on the green color.
• Students with learning disabilities found the plastic tube demonstration amusing. They got out of their seats and wanted to feel the plastic tube

Social Interaction

• Demonstration of the activity by an adult increased students' engagement with it.

Summary

The changes that were made in the dunk activity were very successful in increasing cognitive engagement of students with both learning and multiple disabilities. Using the soda bottle helped students to see more clearly what was happening with the paper towel, and they were better able to connect the activity to the presence of air. The success of this activity appears to rely on the demonstration by a teacher. Even with the adapted version, students were somewhat hesitant to engage in the activity in a hands-on manner. The two alternatives for the flip activity also were well received. Students found the plastic tube activity amusing. Students were also engaged in the "air in the bottle" activity, although access barriers remained for students with physical disabilities.

Given the importance of an adult to facilitate the two activities, further improvements could be made to provide guidelines for teachers as to how to demonstrate the activities, how to scaffold

students' thinking by asking questions, how to encourage students to follow along in the activities in a hands-on manner, how to support student-to-student interaction and collaboration within the activities, and how to assist students in carrying out the activities while at the same time supporting their independence.

3. Respiration Stations

Students' and Teachers' Responses to the Original Activity

Physical Interaction with the Activity

• All students with multiple disabilities participated, including students with walkers and wheelchairs.
• For students with multiple disabilities, adults served as heart, lung, and muscle, and students as red blood cells.
• Many of the students with learning disabilities volunteered to serve as heart, lung, and muscles. Other students took turns serving as red blood cells.
• One teacher of students with multiple disabilities pointed out that sufficient room is required to carry out this activity.

Cognitive Engagement with the Activity

• Students with multiple disabilities were very excited about this activity. Many students wanted multiple turns.
• Most of the students with learning disabilities were excited about this activity as well. There were two students who appeared a bit hesitant to participate.
• At least some of the students with learning disabilities demonstrated an understanding of the circulatory system. Some students knew that the heart has four chambers.
• Teachers of students with multiple disabilities and with learning disabilities facilitated the activity by giving verbal directions or guiding students as to what to do next (e.g., muscle to jump when exchanging balls, directing red blood cells where to go).
• Several teachers of students with multiple disabilities wondered what students got out of the activity. They felt that the activity is useful to prepare students for learning about the circulatory system or to reinforce previous learning about it.

Social Interaction

• The activity requires coordination among multiple players.

Students' and Teachers' Responses to the Adapted Activity

Physical Interaction with the Activity

• Students with learning disabilities were able to do the activity and follow the steps without prompting.
• Students with learning disabilities suggested including other body parts (not just the leg muscle) in the activity.
• Students with learning disabilities suggested using models of actual oxygen and carbon dioxide molecules, rather than representing them with balls.
• Students with learning disabilities reported that they found it hard to keep a beat when making the organ sounds; they suggested having some background rhythm to help keep them on track.

• Teachers of students with multiple disabilities helped to walk the student who was acting as the red blood cell from one body part to another, and told him what he had to do.
• The students who acted as heart and muscle needed reminders about what to do.
• At some point, the teachers of students with multiple disabilities were somewhat confused about the instructions for the activity.

Cognitive Engagement with the Activity

• Students with learning disabilities were engaged and appeared to enjoy the activity.
• Some students with learning disabilities appeared embarrassed to make the sounds of the organs out loud.
• Students with multiple disabilities participated in all aspects of the activity, with assistance from their teachers.

Social Interaction

• The activity requires coordination among multiple players.
• Teachers of students with multiple disabilities facilitated the activity in multiple ways. They assigned roles to students (e.g., heart, muscle, leg), guided them from one body part to the next, and reminded the body parts what they had to do.

Summary

Most of the changes that were made in the activity (using different-sized balls to represent the oxygen and carbon dioxide molecules, using two students to represent different chambers of the heart, and having students who acted as organs make sounds) worked well for the higher functioning students with learning disabilities. While the change in the size of the balls representing the oxygen and carbon dioxide molecules did not appear to change or improve their involvement with the activity compared to the original activity, it did not distract from it. Having two students serve as different parts of the heart appeared to increase their cognitive engagement with the activity, and to help them make connections to the circulatory system. Having students make sounds for the organs did not work as well, as students seemed to struggle with keeping a rhythm and were a little embarrassed by having to do this.

Students with multiple disabilities demonstrated a high level of engagement with the adapted version of the activity. With sufficient space and some of the their teachers' assistance, they were able to physically engage in it. Their level of cognitive engagement was high as well, and due to a teacher's facilitation (she assigned students to serve as the different organs), students participated more in this version of the game than in the original version in which teachers served as the organs. However, students needed frequent reminders and directions about what they had to do (which organ the red blood cell had to move to next, what each organ had to do), and even their teachers where confused at times. It was not clear how much students knew about the circulatory system and whether and how they connected the activities to whatever level of knowledge they had. The change in the size of the balls representing the oxygen and carbon dioxide molecules did not appear to change or improve their engagement in the activity.

Further improvements could focus on providing guidelines for teachers about how to facilitate this activity, especially for students with more severe disabilities. These guidelines could include suggestions for how to help students connect the activity to the circulatory system and how to assist students in carrying out the activities while at the same time supporting their independence.

4. Where the Weird Things Are/Your Creature's Features

Students' and Teachers' Responses to the Original Activity

Physical Interaction with the Activity

• Most students with multiple disabilities who participated in this activity dictated their responses to the teachers.
• Students with learning disabilities struggled with writing their ideas down on paper. They had lots of good ideas about their creature, the environment it lived in, and how its features helped it, but their writing was illegible.
• Teachers of students with multiple disabilities offered several suggestions for improving the accessibility of the activity:

- Eliminate the writing component.
- Give students environments (pictures) to choose from (or give them elements of environments that they can compose).
- Use big pictures, and ask students what part of the picture does the creature live in.
- Give students more specific writing prompts (e.g., ask them to explain how the features are well-adapted to certain environments).

Cognitive Engagement with the Activity

• A small number of students with multiple disabilities (about 5–6) gravitated to this activity.
• Students with learning disabilities were not very interested in this activity (only about half of the group participated).
• When the facilitator showed the pictures of the creatures, some students with multiple disabilities did not look at them. But some students answered some of the facilitator's questions about where the creature lives ("up high," "in the ground"); other questions that the facilitator asked (e.g., "How tall is the creature?") remained unanswered by the students. The teachers jumped in and provided some answers.
• The teachers helped students with multiple disabilities by asking them questions.
• The teachers suggested to some of the other students with multiple disabilities that they color in the pictures of the creatures.
• Teachers of students with multiple disabilities offered several suggestions for improving students' cognitive engagement:

- Keep it simple—focus on one body part and its interaction with the environment.
- Use real animals—picturing something that is not real can be challenging.
- Use simpler creatures (e.g., creatures that can't get wet).
- Give students an example of a creature matched with its environment.
- Give students story starters (words or pictures).
- Make the worksheet bigger and more colorful.

Social Interaction

• The activity did not afford much interaction among students.

Students' and Teachers' Responses to the Adapted Activity

Physical Interaction with the Activity

• The students with learning disabilities said that they liked the "Creature's Features" book. They said that they got a better sense of the creatures because they were in color and had some descriptions. The students also liked that they could access the descriptions through audio or by reading.
• Students with learning disabilities, as well as students with multiple disabilities and their teachers, had some trouble getting the "Creature's Features" book to work (using the pen to hear the audio description). They were assuming that they had to tap the pen when they had to slide it.
• Teachers of students with multiple disabilities suggested attaching the "Creature's Features" book to speakers so that the volume of the audio can be increased. They also suggested increasing the font size of the text.
• A teacher of students with multiple disabilities suggested that students would be better able to participate in this activity if they could share their ideas with a GoTalk machine (https://www.spectronics.com.au/product/gotalk-4) and pictures. It would be helpful to give students a choice of three environments and then have them pick which one would best match the creature. The teachers indicated that students with multiple disabilities benefit from more structure rather than having a very open-ended activity. These students also need to have some vocabulary options.

Cognitive Engagement with the Activity

• Among the students with learning disabilities, only the girls showed an interest in the "Creature's Features" book.
• Students with learning disabilities suggested that the "Creature's Features" book could be enhanced by including more elaborate descriptions. For instance, the book could give hints about the environments and describe the features or the animals in more detail.
• The students with multiple disabilities did not appear to be very engaged by the "Creature's Features" book. When teachers demonstrated it to them, they did not look at the pages.
• The students with multiple disabilities did not appear to pay much attention to the sample plastic animals that the facilitator distributed.

Social Interaction

• Many students with multiple disabilities appeared to need their teachers' assistance to participate in the activity.
• The activity did not afford much interaction among students.

Summary

The changes that were made in this activity (using a colorful, tactile book with audio descriptions instead of line drawings to represent the creatures, and showing children plastic animals to support discussion of how these animals are adapted to their environments) showed mixed results. None of them facilitated students' writing, with which nearly all students struggled. The availability of plastic animals in and of themselves did not appear to increase conversations about animal adaptations. The "Creature's Features" book was well received by the students with learning disabilities, who appreciated the colorful images and the availability of audio description. Students and teachers struggled to some extent with using the pen to make the audio descriptions play, and teachers of students with multiple disabilities suggested

that the book could be enhanced by using larger font sizes and amplification of the audio descriptions. The response of the students with multiple disabilities to the "Creature's Features" book was less clear. Few, if any of them, were able to use the book on their own, and they did not demonstrate much interest in it.

Future changes in the activity must focus on either supporting students' writing or providing them with alternatives to express their thoughts about the environments in which the creatures are living (e.g., describing their ideas verbally, or using assistive technology such as GoTalk). Additional changes could focus on creating versions of the activity that incorporate more student interactions as well as guidelines that give suggestions for teachers on how to facilitate this activity (e.g., how to lead discussions about how an animal's features relate to the environment it lives in).

5. Blueprint for a Beast

Students' and Teachers' Responses to the Original Activity

Physical Interaction with the Activity

• All students with learning disabilities were able to create some representational drawings, even though they differed in the number of details they included.
• Students with multiple disabilities had issues with fine motor/grapho-motor control, which limited their ability to draw.
• Teachers offered multiple suggestions for improving the physical accessibility of the activity:
    - Give students pre-drawn parts that they can assemble.
    - Give students a choice of creatures to glue into an environment.
    - If students can't draw, give them a picture and have them point to a body part.

Cognitive Engagement with the Activity

• A small number of students with multiple disabilities (2–4; mostly girls) gravitated to this activity.
• Most students with learning disabilities were engaged in this activity; 2–3 students took some time to start drawing.
• Some students with learning disabilities drew creatures only; others also drew their environment.
• While students with multiple disabilities paid sustained attention to the task, none of them was able to create representational drawings.
• Teachers' suggestions for improving the cognitive accessibility of the activity included:
    - Keep creatures real (e.g., fish in the ocean).
    - Use environments with which students are familiar (e.g., they may not know what an iceberg or volcano is).

Social Interaction

• Students with multiple disabilities were joined by some of their teachers, who gave them directions and helped them write their names and responses.
• The teacher of students with learning disabilities assisted them by talking to each student, asking them about the environment they chose and writing it down on their worksheet, and by asking questions about the creature and how it functions in the environment. She also asked some students to share what they drew with the whole group.

• Teachers suggested facilitating the activity with guiding questions (e.g., What would I need if I lived in water?).

Students' and Teachers' Responses to the Adapted Activity

Physical Interaction with the Activity

• Some students with learning disabilities used a variety of materials (wiki sticks, clay) to create animals in 3-D.
• The pictures that the facilitator used to show sample environments to students with multiple disabilities (e.g., desert, side of a cliff) were very small, and were difficult to see from the back of the room.
• Teachers of students with multiple disabilities had to assist their students in various ways to participate in the activity. In some instances, the teachers did the entire activity (e.g., create a 3-D representation) for the student. In other cases, teachers assisted students by guiding their hands while drawing, or helping to roll clay.

Cognitive Engagement with the Activity

• Several students with learning disabilities (all girls) engaged in the creating 3-D versions of the creatures with the art materials supplied.
• Some students with learning disabilities did not fully understand the instructions for this activity, and drew pictures from the "Where the Weird Things Are" activity.
• The teachers of students with multiple disabilities were engaged in the reading of the Eric Carle book.
• It was difficult to gauge how engaged the students with multiple disabilities were in the reading of the Eric Carle book. Some of the students did not look up when the instructor showed the pictures. The teachers did not prompt their students to look.

Social Interaction

• The teachers of students with multiple disabilities tried to engage their students in the activity as they assisted them by asking questions such as, "What color pencil would you like to use?" "What should I draw?" "What else does the creature have?" and "Do you want to use a different color?"
• Students with multiple disabilities did not share their creations with the group.

Summary

The changes made in this activity (the use of the Eric Carle book, the supply of a greater variety of arts materials, asking students to share their animals with the group) met with mixed success. The greater variety of materials increased the physical accessibility of the task, but did not appear to increase the cognitive engagement with it. Girls appeared to be more attracted to both versions of the activity than were boys. The Eric Carle book was successful with the teachers of students with multiple disabilities, but it was not clear if it had any impact on their students. The students did not share much about their creations, and the activity prompted little discussion about their animal's adaptation to the environment.

Additional changes could focus on creating versions of the activity that incorporate more student interactions as well as guidelines that give suggestions for teachers on how to facilitate students' cognitive and social engagement with this activity (e.g., how to facilitate an exchange of ideas regarding animals' features and their relationship to the environment they live in).

Summary and Conclusions

Overall, we found that student participation and engagement in the five Kinetic City activities was high, regardless of students' disabilities. The adaptations that were made in the activities were successful in improving their accessibility, at least for some students. However, some access issues remained. For instance, the writing activity remained inaccessible to students with both learning and multiple disabilities. In some instances, students were not fully aware of the existing adaptations (e.g., the availability of keyboard controls, or how to use the talking pen with the "Creatures Features" book), which limited their use of these adaptations. In another instance, we observed that an adaptation that improved access for some students created new obstacles for other students (i.e., the digital scale used in the revised Dunk and Flip activity was difficult to read for students in wheelchairs because of their angle of vision). These findings highlight the importance of conducting multiple iterations of user testing, the need for making students aware of access options, and the need for multiple versions of learning activities.

Our observations also highlight the importance of adults in mediating learning activities, particularly for students with more severe disabilities. Teachers, program leaders, and other adults working with students with disabilities need instructions for how to effectively facilitate the activities for students with different kinds of disabilities in ways that encourage students' independence and that promote physical, cognitive, and social engagement.

References

Reich, C., Price, J., Rubin, E., & Steiner, M. A. (2010). *Inclusion, disabilities, and informal science learning.* Washington, DC: Center for the Advancement of Informal Science Education (CAISE).

Appendices

1. Parental Consent Forms

2. Teacher Consent Forms

3. Teacher Interview Protocol

Appendix 1: Parental Consent Forms

Education Development Center, Inc.

Parent/Guardian Permission Form
Kinetic City Empower Research Study

The Education Development Center, Inc. (EDC) is a nonprofit research and development organization dedicated to improving the quality, effectiveness, and equity of education. The American Association for the Advancement of Science (AAAS), is an international non-profit organization dedicated to advancing science around the world by serving as an educator, leader, spokesperson and professional association.

Purpose of the study: We are conducting research to develop Science, Technology, Engineering, and Mathematics activities that can be used by students with disabilities. The study is funded by the National Science Foundation.

Description of the Research: This study will take place at your child's school. Participants will try out five science activities developed by AAAS. We will do the activities over two two-hour sessions. To understand more about students' interests in science, technology, engineering, and mathematics; and to learn students' opinions about the science activities; we plan to do interviews or ask students to respond in writing to questions, whichever format they prefer. Each interview or written response session will take about 10 minutes during each of the four sessions. Interviews will be audio recorded and transcribed. This study will not result in a decrease in instructional time.

Benefits: Your child may benefit by enjoying the activities, and his or her responses will contribute to efforts to make the science activities more accessible for students with disabilities.

Risks and Confidentiality: The data from this study will remain confidential. Participation will involve minimal risk associated with breach of confidentiality. We will make every effort to minimize this risk. Audio recordings from the interviews will be transcribed and audio files will be deleted at the end of the study. Audio recordings and transcripts will not contain your child's name, and will be accessible to research staff from EDC and AAAS only. Interview statements may be quoted in the final evaluation report, but participants will not be identified by name or described in such a way that they can be identified. The results of the study, and therefore excerpts of interviews, may be presented at scientific meetings and in published reports for educational, policy and scientific purposes. Upon your request, you will be informed about the results of this study.

Costs and Compensations: It will not cost your child anything to be in the study. Your child will receive a $25 gift card at the completion of the four sessions.

Your Rights: Participation in this research is strictly voluntary. Your child is free to not answer any question they choose not to. Should your child choose to discontinue his/her participation in the study, he/she can withdraw at any time without penalty or loss of benefits after signing this form. Parents please be aware that under the Protection of Pupil Rights Act. 20 U.S.C. Section 1232(c)(1)(A), you have the right to review a copy of the questions asked of or materials that will be used with your students. If you would like to do so, you should contact Babette Moeller at (800) 225-4276 ext 4205 to obtain a copy of the questions or materials. You may also use this number to contact Babette Moeller if you have any other questions about the research. If you have any questions regarding your rights as a participant in or concerns about this research, you can contact EDC's Human Protections Administrator at 1-800-225-4276 ext. 2971 or HumanProtections@edc.org.

You will receive an extra copy of this permission form for your records.

_____Yes, I agree to have my child participate
_____No, I do not give consent for my child to participate

_____ _____
Your Child's Name (please print) School Name (please print)

_____
Name (please print)

_____ _____
Signature Date

96 Morton St. ● New York, NY 10014 ● Phone: 212.807.4200 ● Fax: 212.633.8804 ● www.edc.org

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Purpose of the study: We are conducting research to develop Science, Technology, Engineering, and Mathematics activities that can be used by students with disabilities. The study is funded by the National Science Foundation.

Description of the Research: This study will take place after school at your child's school. Participants will try out five science activities developed by AAAS. We will do the activities during two one-hour sessions. To understand more about students' interests in science, technology, engineering, and mathematics; and to learn students' opinions about the science activities; we plan to do interviews or ask students to respond in writing to questions, whichever format they prefer. Each interview or written response session will take about 10 minutes during each of the two sessions. Interviews will be audio recorded and transcribed. This study will not result in a decrease in instructional time.

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Appendix 2: Teacher Consent Forms

Education Development Center, Inc.

Teacher Interview Consent Form
***KC Empower: Universal Access to After School STEM* Research Study**

The Education Development Center, Inc. (EDC) is a nonprofit research and development organization dedicated to improving the quality, effectiveness, and equity of education. The American Association for the Advancement of Science (AAAS), is an international non-profit organization dedicated to advancing science around the world by serving as an educator, leader, spokesperson and professional association.

Purpose of the study: We are conducting research to develop Science, Technology, Engineering, and Mathematics activities that can be used by students with disabilities. The study is funded by the National Science Foundation.

Description of the Research: The research involves interviews with teachers of children with disabilities to learn about their students' interests in Science, Technology, Engineering, and Mathematics (STEM), and about whether adapted versions of five STEM activities are accessible for youth with disabilities. As part of this study, and with your permission, you will participate in up to two brief interviews during two activity sessions that will take place at your school. Each interview will take about 15 minutes. The interviews will be audio-recorded.

Benefits: You may benefit by helping to make the STEM activities more accessible for students with disabilities.

Risks and Confidentiality: The data from this study will remain confidential. Participation will involve minimal risk associated with breach of confidentiality. We will make every effort to minimize this risk. Audio recordings from the interviews will be transcribed and audio files will be deleted at the end of the study. Audio recordings and transcripts will not contain your name, and will be accessible to research staff from EDC and AAAS only. Interview statements may be quoted anonymously in the final evaluation report, but participants will not be identified by name or described in such a way that they can be identified. The results of the study, and therefore excerpts of interviews, may be presented at scientific meetings and in published reports for educational, policy and scientific purposes. Upon your request, you will be informed about the results of this study.

Costs and Compensations: It will not cost you anything to be in the study. Your school will receive a $25 gift card at the completion of the four sessions.

Your Rights: Participation in this research is strictly voluntary. You are free to not answer any question you choose not to. Should you choose to discontinue your participation in the study, you can withdraw at any time without penalty or loss of benefits after signing this form. If you have any questions about this research, you can contact Babette Moeller at (800) 225-4276 ext. 4205 to obtain a copy of the questions or materials. If you have any questions regarding your rights as a participant in or concerns about this research, you can contact EDC's Human Protections Administrator at 1-800-225-4276 ext. 2971 or HumanProtections@edc.org.

You will receive an extra copy of this consent form for your records.

_____Yes, I agree to participate
_____No, I do not wish to participate

_____ _____
Name (please print) School Name (please print)

_____ _____
Signature Date

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Teacher Interview Consent Form
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Description of the Research: The research involves interviews with teachers of children with disabilities to learn about their students' interests in Science, Technology, Engineering, and Mathematics (STEM), and about whether adapted versions of five STEM activities are accessible for youth with disabilities. As part of this study, and with your permission, you will participate in up to two brief interviews during the two activity sessions that will take place afterschool. Each interview will take about 15 minutes. The interviews will be audio-recorded.

Benefits: You may benefit by helping to make the STEM activities more accessible for students with disabilities.

Risks and Confidentiality: The data from this study will remain confidential. Participation will involve minimal risk associated with breach of confidentiality. We will make every effort to minimize this risk. Audio recordings from the interviews will be transcribed and audio files will be deleted at the end of the study. Audio recordings and transcripts will not contain your name, and will be accessible to research staff from EDC and AAAS only. Interview statements may be quoted anonymously in the final evaluation report, but participants will not be identified by name or described in such a way that they can be identified. The results of the study, and therefore excerpts of interviews, may be presented at scientific meetings and in published reports for educational, policy and scientific purposes. Upon your request, you will be informed about the results of this study.

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You will receive an extra copy of this consent form for your records.

_____Yes, I agree to participate
_____No, I do not wish to participate

_____ _____
Name (please print) School Name (please print)

_____ _____
Signature Date

Appendix 3: Teacher Interview Protocol

Teacher Interview Questions

Goals:
1. To learn about your students' interests and preferences for afterschool STEM activities.
2. To obtain input about the appeal and accessibility of selected KC Empower activities.

1. Students' Interest and Experiences in Afterschool Science Programs
Have you engaged in STEM activities with your students who have disabilities? What are your thoughts about their ability to fully participate? What do you think would make STEM more exciting for students with disabilities (probe for content/topics, types and level of activities)?

What interests your students, especially those with disabilities, about Science, Technology, Engineering and Mathematics (STEM)?

What topics/content are they interested in?

What STEM activities do they like?

What do they NOT like?
What kinds of technology do your students like to use?

What are barriers that may get in the way of your students' technology use?

What are your suggestions for resolving this issue?

What kinds of difficulties might students with disabilities come across in afterschool or summer STEM programs?

What suggestions do you have for making afterschool or summer STEM programs more accessible for students with disabilities?

2. Students' Responses to KC Empower Activities

How did you like the activity? How do you think students will like it?

How would you use the activity in your program?

How easy or difficult do you think it will be for students with disabilities to read and follow the instructions?

How easy or difficult do you think it will be for students with disabilities to do the activity?

What do you think students will learn from the activity?

How could the activity be changed to make it more interesting for students with disabilities (probe for presentation of the activity, content/topics, types and level of activities)?

How could the activity be changed to make it more usable/accessible for students with disabilities?