Recycled ToyRobot (from the SciFest experience)

Age and Level:

SciFest is a scientific faire, that attracts thousands of visitors every year. There are companies, schools and departments from university who are running the workshops, experiments or presenting showcases and their products/services which is related to science, engineering, technology, arts and crafts, mathematics, and other subjects taught at schools. One of the workshops of SciFest was dedicated to creating recycled robot heads (and bodies!) out of cardboard boxes, plastic bottles, and other available, easy to find everyday materials. Idea of the workshop was to engage not only kids who are enthusiastic about technology, but also kids who are interested in arts and crafts. Sonja also observes that 10-16-year-old kids can take part of this workshop. For more advanced students, there is the opportunity to choose tasks that are more challenging. Robots are very familiar, especially for boys, but hardly in any place, have kids built up a robot head from the recycled materials. Some kids are also familiar with programming, but Sonja notices that especially it is hard to engage girls and some boys for this activity; they think that it is boring. Therefore, Sonja thinks of modifying her idea to let the kids in her club to use their imagination to create/bring to life their own version/conceptualization of what a 'robot' is by making their own Recycled ToyRobot. This could attract the interest of a wider group of boys and girls. The workshop was about making and hands-on activities, with the aim of attracting a wide variety of girls and boy (e.g., those who are not so interested in technical activities such as programming). This was to emphasise that robot building is more than programming. Sonja, an after-school crafts and arts club instructor, is very interested in handcrafts and she likes to make things by herself, because then what she makes is personalised and has her signature. She is not interested in ready made products and has not had interest in programming. She wants to teach her club kids to be creative and that they can recycle things for creating something new. She and other colleagues from the club are observing and participating in the RoboHead workshop in SciFest, involving themselves in a short hands-on activity to understand how this workshop could be run with the kids at the club.Sonja also observes that 10-16-year-old kids can take part of this workshop. For more advanced students, there is the opportunity to choose tasks that are more challenging. Robots are very familiar, especially for boys, but hardly in any place, have kids built up a robot head from the recycled materials. Some kids are also familiar with programming, but Sonja notices that especially it is hard to engage girls and some boys for this activity; they think that it is boring. Therefore, Sonja thinks of modifying her idea to let the kids in her club to use their imagination to create/bring to life their own version/conceptualization of what a 'robot' is by making their own Recycled ToyRobot. This could attract the interest of a wider group of boys and girls.

Primary Actors and main goal:

The primary actors will be the instructor (Sonja), the students (boys and girls). Instructors are concerned about the feedback they receive from the parents (secondary actors). Parents are little bit concerned about programming, because kids are playing with the computer for long periods of time. However, parents appreciate that the SciFest activities that they have the opportunity to see (and test if they wish) are more than just programming with the computer, more creative activities are performed. Main goals of the Recycled ToyRobot scenario are to boost kids' creativity, problem solving and team skills as well as to demystify the use of technology while keeping in mind ecological perspectives (using recycle materials for building new toys/things/robots). Furthermore, girls enjoy being creative using crafts and arts, as well as some boys, too. Technology could be attractive for boys more than for girls, but it might be that when integrating crafts and technology, all kids can find that there is something they are keen to make/create and enjoy.

Topic and Content:

In the Recycled ToyRobot activity, kids are asked to plan and design their own version of what a robot/toy is, using recycled materials, such as paper rolls, boxes, plastic yoghurt mugs. An interactive part of the toy, such as the eyes, will be made using LEDs (light-emitting diodes), which will be programmed to blink at a certain rate. At the beginning of the activity, the kids are given the instructions, they form groups and are introduced to the five stages of craft- and project-based learning (ideate, plan, create, program, share). They are also asked to follow the instructions about how to make the LEDs blink. There are 3-4 students in each group and each group has their own PCs and Arduino kits at the table as well as different recycled materials, pencils, glue, scissors, colour paper, foil paper, etc. Each group is designing their own version of a ToyRobot and how the eyes of the robots will blink or how lights in the eyes are on or off.

Description of environment and possible pre-conditions:

Kids can perform the activities within 1.5 hours (however 3D printing is not included to this activity). The feedback received from the students that participated in the SciFest version of the activity indicates that some students wouldlike to involve 3D design and made the robots more professional looking. This implies that the activity could be set to be developed in longer time (2 days or more), so that kids really have a chance to carefully design and take longer time to make/create their ToyRobot. The robot building activity originally took place at SciFest, an inspiring environment, where the students can get comments and feedback as well as ideas from the audience and professionals visiting the event. There could be open place for everyone to join in, use the materials and get instructions and help when necessary. The activity is based on STEAM subjects, which serve well the curriculum of schools. However, more students might be interested when receiving the information about the workshop. Using social media and school network more efficiently could help to reach the wider audience.

Preparatory work:

For the activity, an instruction manual of the steps to follow when using the virtual programming environment (Snap4Arduino) needs to be prepared.
Also, during the workshop, an Arduino Uno board connected to a Raspberry Pi3 computer was set up, as individual work stations for each group. When other software is needed, if there are no restrictions of installation, it is easy to install. The instructors should check that the necessary software are pre-installed and the programs run. In addition, recycled materials as well as crafts materials should be collected and made available during the activity development.

Description of Activity:

The instructor starts with a short introduction about what kids are supposed to do, what the process is and what the materials and tools to use are. The students are asked to form groups of 3-4 students and take a work station (Arduino board connected to a Raspberry Pi PC) and start working. In the SciFest version of the workshop, one group designed a square robot head, where the robot eyes are blinking one after another. Another group designed an elephant robot head - big eyes were supposed to be 3D printed, where the LEDs are set in the middle. Since there was not 3D printing available, the students set for using cardboard to create the eyes of the elephant. Students planned themselves, which recycled materials they need. They also decide what part they need to 3D print for the head. Students are dividing the tasks among themselves, and when the group member struggles with a task, the other members are ready to help: they seem to solve the problems by themselves. Instructions are following the processes and especially in 3D designing and printing students need more guidance, because it is new for them all. Some problems with properly printing the 3D design meant that they needed to try printing again after adjusting their design. The instructor is helping by not giving direct answers but leading the group to check their design in order to print it correctly. At the end of the activity, the groups present and explain their creations for everyone else to see.

Other Stakeholders and their possible Interests:

Parents who provide positive feedback to their kids. Creative designers and makers with a positive attitude. Results also might interest companies and investors who might appreciate to have inspirations from young people.

Success and condition:

At the end of the workshop/activity, all groups are asked to present their creations to all and asked feedback about the implementation. Teachers experience that they have not seen the students working so well together and being so engaged on that kind of learning process. Even the girls were excited about the hands-on activities and arts and crafts and their ToyRobots look well designed and carefully made. As the groups got more experience they started to talk about how they could design and make more advanced ToyRobots, which would be more complicated and high-design product that reacts to voice, movement or light changes in the environment.

Failure and conditions:

Time considerations for taking the project to completion. For instance, during the SciFest experience, there was one group, where one of the group members had to leave earlier and the other two were not able to decide how to continue with the activity. Their robot head was a simple one and it seemed that the two members were not happy about the result: it was not the product they designed in the first place.

Barriers/Facilitators:

Barriers
Are the groups working well?
Grouping makes difference, to get students to work well with each other and make sure that they have time to work on their ToyRobot.
Is the given time sufficient for the workload?
Tracking the time is important. The students need to understand that the amount of time they have and the workload will be in good balance.
Do the students have the information they need to succeed? Role of the instructor/teacher/coach
A limitation arises if the students do not have any idea about how to build a ToyRobot and creativity is missing. The instructor is to intervene: how to guide them to be free of the limits set by their own mind set.

Facilitators
Motivation
Some students were keen on the idea that they can create and make a real product by themselves.
Peer networks and Internet Information finding, a powerful tool to fuel creativity.

Extensions:

From the robot head workshop to the ToyRobot activity the robots can advance towards becoming more interactive and reactive to changes in the environment. For instance, creating a robot alarm to wake the person up when it is day time; a robot guard to sound an alarm whenever someone trespasses a forbidden room; a talking robot that reacts to the close presence of people; etc.

Variations:

Some students would like to design projects with the LEDs lights embedded to the accessories of clothing.
Students started to think also how they could for example help the elderly people for having them the robot with blinking eyes, when their phone is ringing in the other room.

The flash light school bag

Age and Level:

Veikko is a 12 years old student in Helsinki. He goes twice a week to swimming training, likes techno music but he is also fond of online games and computers. With the age of 10 he got for Christmas a Lego robot and with the help of his father – an engineer – he managed to get the robot going.

Primary Actor and main goal:

At school he acquired some basic programming skills already. Veikko also has a younger sister that just started school. Since they live a bit outside of Helsinki, both have to leave early in the morning to go to school. Especially in winter it is still dark when they leave home.

Topic and Content:

Veikko has an innovative teacher who launches different projects. This month the teacher got some Arduino boards to launch different projects. He understood that with Arduino you can programme many different things and combined with sensors he can create many things with different functions.

Description of environment and possible pre-conditions:

Veikko's teacher has asked them to build pairs and agree to a small project they would like to create. Veikko and his friend Pekka would like to do something of real usage that goes beyond playing or fun. Veikko and Pekka elaborate a plan to 'pimp' school bags: since they are leaving so early from home it is difficult for cars to see school kids in the dark, especially when there are no reflectors attached to the cool bags any longer (which leads often to discussions with his parents).
Thus, Veikko and Pekka decide to build a sensor for the school bag that would start flashing on his school bag once the light becomes low.

Preparatory work:

The teacher asked them to prepare a sort of 'concept' that outlines the idea behind, the usage, the materials and skills as well as knowledge they will need a.s.o. Thus, Veikko and Pekka start to investigate which components they would need and establish the list materials, the sensors, the LEDs they would need, a.s.o. The boys also consider the different circumstances for the design (ie. snow and rain on the sensors and the Arduino board, ...). They hand over their written plan to the teacher and discuss with him the outline.

Description of Activity:

Four days later, the teacher has ordered the needed Arduinos and each of the students have brought additional materials with them. Veikko has brought his old school bag for testing since he is not sure how to attach the LED lights, if he would need to make some holes in the bag, a.s.o.

The teacher helps him plan how to mount the LED lamps on the bag, and also reminds the students they need to insulate the component legs to avoid a short circuit. Before they start building, the teacher helps the students to test the photo sensor with one LED, as a 'proof of concept'. They search online for how to connect the components on the breadboard, and use an Arduino example sketch that reads analog values and maps them into the range suitable for LEDs. They learn about statements, and how to set a threshold for the lights to turn on. After the core concept has been prototyped, the teacher asks the woodwork teacher to help the students solder the parts together. The teacher has helped them draw a circuit on paper to aid them as they solder everything together.

Once everything is connected, it won't light up. The students are very disappointed, and are not sure what to do next. The teacher tries to cheer them up, and shows them a systematic approach to troubleshoot the error. They use the serial monitor to make sure they are getting values from the sensor, and that the threshold is properly set. After that, they upload a code to light up the LEDs only. They don't light up, and one of the students suddenly finds it's because they have not properly insulated the LED legs. Once the whole circuit has been properly insulated, all the technology is working as planned.

Other Stakeholders and their possible Interests:

As Veikko tells in the evening what he has done at school his sister also would like to have some flashing LED lights installed on her bag.
Veikkos realizes that the lights might need improvement in terms of design if used by smaller kids so that all the components are hold within one case. By creating this, the Arduino construction would be more stable than his initial installation and design. Thus, he designs a case in the 3D printing programme TinkerCAD.
His teacher allows Veikko to use the 3D printer at school to improve his project. During the creation of the case, there are a lot of errors to resolve at the beginning of the process to get the 3D model to print correctly. However, once in a while, the printing process fails, and Veikko has to discard the spoiled material and start the sequence again. Finally, Veikko managed to have the case printed and installs the Arduino in the case.

Success and condition:

One week later Veikko is allowed to take his LED lights home for his sister. Together with his mother, they only need to sew a Velcro stripe on the outside lunch box case of his sister schoolbag. Veikko connects the cable with the components in the case, turns off the lights and immediately the LED lights start blinking.

Variations:

This type of scenario, where learners try to find the solution to a problem relevant to their everyday life has the power to engage them in a completely different way.

Greenhouse

Age and Level:

Jenna is a 13-year-old student in Helsinki. She cares deeply about the environment, and loves to take care of plants and animals. Her favourite school subjects are all related to natural sciences, and she is an independent learner who reads a lot about things she finds interesting in her spare time.

Primary Actor and main goal:

At school she has been introduced to programming and basic electronics, but since she didn't understand it instantly it affected her self-confidence. Jenna, having a perception of herself as a fast learner, is starting to think this is not her subject. She has also noticed that some commonly low performing students in her class seems to excel at these subjects. She wants to prove herself, but at the same time relate it to her interests to make it more motivating and meaningful for her.

Topic and Content:

Jenna's teachers, one technology teacher and one math teacher, want the students to work more cross curricular. This is the first year that they try to involve electronics and programming in their work together, and none of them have much experience.

Description of environment and possible pre-conditions:

The students are asked to work in pairs to realize their projects. Jenna wants to work with her best friend, Aina. They share similar interests, and as they have been introduced to Arduino and programming, they have also asked their parents to buy electronics to that they can learn at their own pace at home. Soon, Jenna and Aina agree that they want to build an automated greenhouse.

Preparatory work:

The teachers are not sure how to help them, they have only bought some kits with components and are not sure their idea can be realized. Most students have much simpler ideas, that the teachers can help to realize. Aina's father, who works in IT, knows about Arduino and Raspberry Pi, so he decides to help the girls order the material needed. He is later contacted by the teachers, so that he can share his knowledge on where to find components and educational resources with them.

Description of Activity:

Once the material has arrived, Jenna and Aina have a systematic approach towards testing them and putting everything together. As per Aina's father's advice, they split their problem into small parts, and test the solutions separately. Since they are both independent learners, they can find most information needed to build and code the core parts of their project by themselves. They test the light sensor first, to learn what values they receive in different light conditions. They then try the temperature sensor, and explore different way to build your own humidity sensor. Aina's father helps them to filter the captured data to make the values more stable.

Other Stakeholders and their possible Interests:

After spending some time realizing their spare time project, they decide to bring it to school to show it to their teachers. The teachers are impressed, and have Aina and Jenna present their project to the class. They also try to understand what resources and knowledge will be needed for themselves to support similar student projects to be created in school.

Success and condition:

The teachers learn that Aina and Jenna were able to build a more complex project not only because they had Aina's father as a support, but because they came into the project with no idea of how feasible it was. They were also able to realize the project independently as they did it at their own pace, driven by their own motivation and interest in the final result, and since they were both independent learners. In the end, Jenna and Aina had as much electronics knowledge and skills as the high performing students in the same subject.

Failure and conditions:

Without Aina's father helping out, the girls would not have had the support needed to finalize their project. The challenge for the school would be to make this visible, and provide the appropriate support. Jenna and Aina would perhaps not have had the opportunity to understand that they were as able as their other classmates in regards to hands-on technology. The eCraft2Learn systems ability to put the learners in direct contact with experts would make this scenario possible for more students.

The prank machine

Age and Level:

Elias is a 14-year-old student in Helsinki. He has a hard time concentrating in the classroom, and has started to skip some classes to hang out with friends around town. His main hobby is playing online video games with his friends. Since he has a lot of experience that he is also good at sharing, he is the leader of two MMORPG guilds. He has his own game oriented YouTube channel, and has gained around 200 followers since he started a year ago.

Primary Actor and main goal:

His technology teacher has started to introduce the class to Arduino. To her surprise, Elias who has stopped attending her Physics class, is excelling at Arduino and electronics. Although he is dyslexic, he seems to have little trouble programming in the Arduino IDE.

Topic and Content:

As Elias's teacher had the students create their own technology projects, she noticed Elias' ideas were standing out, but seemed very complex to carry out. She still wanted to find a way to support his enthusiasm. Since he learned so fast, she made him and another one of his classmates, mentors for the other students.

Description of environment and possible pre-conditions:

The teacher plans it so that her students can come up with concepts 6 months before the deadline in December. Although she does have a small lab with basic electronics components that she started to build up two years ago, she knows final projects often meant materials had to be ordered. Since some components had to be ordered from China, sometimes with weeks of shipping time, she made sure to collect material lists as early as possible. This year, as she had started to collaborate with the woodwork teacher, she had a bigger budget for materials, and planned on buying some soldering irons, wire strippers, as well as a laser cutter. After some lessons learned from the previous year, they had decided to collaborate later in the project, to make sure everything got finished in time for Christmas.

Preparatory work:

The teacher asks the students to prepare a sort of 'concept' that outlines the idea behind, the usage, the materials and skills as well as knowledge they will need. As Elias is planned to help out with a range of his classmates projects, he also agrees to simplify his own idea.

While other classmates are planning to create functional projects, Elias wants to create something fun. His teacher had something different in mind, but decides to avoid discouraging Elias, now that he is finally enthusiastic about a school topic. Elias wants to create a prank machine, so that he can film his prank victims for his Youtube channel.

His teacher helps him discard offensive pranks as well as pranks that are too technically complex for the time at hand. In the end, the idea is to create a machine that senses when someone comes close to the school Christmas tree, and that triggers the song 'Last Christmas' at the same time as the Christmas lights start to animate in disco-like patterns.

Description of Activity:

As students are doing research on components needed, some have to change their concepts based on technical limitations and material cost. One project planning to use five servo motors and three ultrasonic sensors is completely discarded. Although it is expensive, Elias wants to order an mp3 shield for his project. His teacher knows that the best way to easily control several LED lamps is through using an addressable LED strip, so she helps him order addressable LED christmas lights.

As the ordered materials arrive, the students prototype and test them to learn more about the components they are planning to use. Elias is quite disappointed as he notices the mp3 shield uses so many pins on his Arduino board that he can't fit the other components and functions he wants in his project. He decides to use two Arduino boards, and brings the one he has personally brought to school.

Starting out, he tries out the mp3 shield with a special code library he has found online. Once he gets it working, since he found there to be few pins and power left for the sensor he had planned, he decides he will craft his own push button to trigger the song. The teacher helps him find tutorials online, and makes sure the textile teacher can allocate some time to help out ordering materials and sewing the button. Elias then finds resources online for how to connect and control the addressable LEDs he has ordered. He uses a PIR sensor to trigger a light animation when someone was close to the Christmas tree. The e-textile push button is made to be a carpet in front of the christmas tree.

Other Stakeholders and their possible Interests:

As Christmas break is approaching, Elias has his Christmas prank installed in the school's main hall. One day he decides to film the reactions, and edits a compilation of the best reactions. With the consent of the ones depicted, Elias then shares the compilation on his Youtube channel. It is spread locally in the school, giving him more followers, and it is suddenly shared on a famous blog authored by a "Maker".

Success and condition:

After some time, Elias starts to explore a new identity as a Maker. He contacts the blogger, and continues to expand his network as well as work on more advanced projects.

Failure and conditions:

It is being challenging for the teacher to evaluate the student projects according to the learning goals. Since the student projects are not framed by neither theme/topic nor technical solution, the variation of outcomes might make them challenging to realize and evaluate.

Variations:

The brief given was kept open, but could have been tied to specific technical solutions or related to certain theoretical topics

Air pollution measure box

Age and Level:

Anna, 39 years old, is a second-grade student teacher for Biology, Maths and Physics in Austria. The new system of 'Neue Mittelschule' is meeting very much her personal way of teaching. A personal attitude of her being as teacher is to enable and empower students and connecting theoretical knowledge with practice. Thus, she is balancing her teaching a lot with different teaching methods and pedagogical approaches. She also tries to foster team work amongst the students since she is convinced that this is a core skill for the next generation. She tries hard to integrate the obligatory curriculum plan with the student projects, and is getting better at this every year.

Primary Actor and main goal:

Anna lives on the countryside in the mountains. Since ozone pollution is higher in the mountains, she plans to raise the awareness of her students towards air pollution. Last year she had everyone collaborate on the same project, but this year she wants the students to be freer to come up with their own ideas. She decides that all projects need to incorporate some specific technical components, and that they need to bring awareness of the invisible concept of air pollution.

From previous projects she knows that most of her 14-year-old students only have very basic skills in electronic or even programming, but all of them are very capable to handle different programmes. Some of them did amazing crafting the year before. As for herself, she has to confess that her abilities in programming or crafting is limited thus she is aware that she would need very clear and detailed instructions to get started on a project. Some time ago she talked to her colleague Mike who teaches IT in the class and he was willing to collaborate in case she finds an appropriate project that fits also to the IT curriculum. Together, they agreed all students would need to technically incorporate at least one sensor input, and any type of output. Apart from that, the students would be free to innovate.

Topic and Content:

Searching on the internet, she discovers the eCraft2Learn platform and decides it's the perfect tool for her students since it supports team work. It provides her a frame for how to plan for her current as well as future student project assignments.

Reading on the instructions, she understands that she will need to provide prior to the project, some theoretical background knowledge to air pollution but since these fit well with the current school year curriculum she continues reading the other teachers experiences that have been shared on the eCraft2Learn platform.

Description of environment and possible pre-conditions:

Anna and Mike start by looking through the electronics and tools inventory from last year, to sort out all broken components. This takes longer than expected, and Anna decides that next year she will do this as soon as the term has ended.

After they have spent some time researching what materials and tools to purchase for the pollution theme, Anna calculates the related costs for materials needed. After making sure the cost falls within the yearly budget, Anna pays a visit to the local electronics store in the outskirts of the town. She spends the following days sorting components into compartments boxes, and makes sure to label all components and resistor values. She learned this from last year, as all components and resistors quickly became a mess.

Mike makes sure to update the computer rooms software with the latest version of the Arduino IDE. He also makes sure all students have access to the eCraft2Learn platform that has been installed in the classroom.

Preparatory work:

Two weeks later Anna starts with the educational content preparations. She decides to give some first initial input before starting the project in order to allow the students to gain a broad context of pollution, talking about atmospheric ozone, carbon dioxide emission, methane gas, and other substances that affects air quality.

Starting out, she wants all students to follow instructions to connect an Oxygen(O_2) gas sensor, to read the values with an Arduino. This ensures individual assessment. For the project, she and Mike then give them the exercise to use incoming sensor values, from a gas sensor of their choice, to control an LED, a motor, a Piezo, or any other component. This, along with an explanation of what their code did, was the minimum technical solution and deliverable they needed to implement in order to pass Mike's IT class learning goals.

Anna, on the other hand, was more interested in the biological pollution aspect, as well as the introduction of mathematical concepts such as $<$ (smaller than), and $>$(bigger than) being used in the conditional statements. Other than that, she is also interested in how well they are able to collaborate and execute a project in groups, and plans to have the students keep a log of what they are doing. She later finds this type of activity tracking is partially integrated into the eCraft2Learn system.
She books the IT room and the crafting room in accordance with Mike, gets the o.k. from the headmaster and organizes the needed materials (Arduino boards, jumper wires, breadboards, gas sensors, and various other electronic components).

Description of Activity:

Anna gives her students the task to learn about air pollution. She splits her students into eight small groups, and ask them students to list causes, solutions, and to locate what gases are polluting the environment, and how. The students are told to work in groups to visualize the findings in one poster, and are then paired with another group to present their findings. The paired groups are then instructed that they now work together, and that they are supposed to create an interactive system that can detect one or more types of air pollution, and then carry out one or more actions(outputs). The teams brainstorm, present their ideas, and are given feedback on them based on relevance, usability, and feasibility. The concepts students have created are;

- A sensor box that opens a window when CO_2 levels are too high
- A fart (methane gas) sensor that makes a Piezo beep as a threshold is reached
- An Ozone map (built to represent ozone levels in different areas around the school)
- "Bach's air" - a portable instrument made out of sensors. The different inputs are transformed into tones for different instruments or music loops.

Anna and Mike meet the teams one by one, to help them iterate their ideas, and to understand what tools and materials they will need to complete the projects. After a few days, the 4 teams meet in the drafting room. Anna and Mike have brought the materials each group needs, meaning the practical part of the project has begun. Students take on different roles in the teams, and to ensure everyone are actively involved, they meet with the teams and have them describe their work. every week. The teams are encouraged to solve the problems they stumble upon on their own, and during the weekly support meetings they mainly get hints and links to relevant resources. They can also book Mike for an hour to help out with the soldering of the circuits.

Most groups have similar problem, such as dealing with gas sensor warm-up time, and setting appropriate threshold values. Some groups want to build their electronics into boxes, and get help from the wood crafting teacher. Anna and Mike decide to plan for her to be on board for the projects next year.

After five weeks it is time for final presentations. The students are asked to give a background description based on their initial research, demonstrate their prototype, and to talk about what they've learned throughout the process. One group of students are not finished, and their prototype is only half done.

They are asked to present their project later, and are told they cannot get the top grade for their project.

Other Stakeholders and their possible Interests:

As the wood craft teacher is contacted by the students to help them build cases for their electronics, she starts to imagine ways to incorporate these types of projects in her curricular activities. She starts to think about complex mechanical structures, as well as product design angles.

After discussing her thoughts with Mike and Anna, she decides that a laser cutter and an Ultimaker 3D printer should be purchased for next year. They also agree to collaborate more the following year, and have at least three cross curricular student projects that can be executed in a similar way.

To ensure their hours can be scheduled in synch to make this happen, they talk to the school principal. The principal is positive to this development, and encourages the teachers to present this at the next teacher meetup so that it can inspire other subject teachers to do the same.

Success and condition:

One week after the project is over, the last student group is able to demonstrate their prototype and get their grade. They are asked to write a post mortem to reflect on what they could have done different to deliver on time. In the end, all four teams were able to conduct research, create concepts, realize their ideas, and present their project and share what they learned to the class.

Failure and conditions:

Anna and Mike learned that their schedules needed to be more in synch, that they lacked the time, knowledge, materials and tools to build the electronics into physical objects. It was hard to keep track of the students' individual contributions to the teams, and this was something they wanted to improve for the following year.

Extensions:

Some students started tinkering after school, and would create interesting devices at home.

Variations:

The brief given to the students could be made more defined or open depending on the topic. The themes and topics could be varied as well.