Different pedagogical models using tech

Case of STEAM Programs Using Arduino
source: Cuartielles, Goransson - 2011
IxD is a discipline looking at the interaction between [non] humans by means of digital artifacts [products and services].
IxD is well-established

- There is both professional and academic development possibilities when taking the IDM.
- All IT companies hire interaction designers.
- More and more product-centric companies incorporate IxD.
- There is plenty of academic literature in the field.
- The discipline is linked to others such as psychology, engineering, sociology, product design, fine arts, etc.
IxD @MaU

- Programme existing since 1998.
- Exists both at BSc. / MSc. / PhD. levels.
- Alumni at all relevant sectors of the industry, but also within many of the main academic institutions world-wide.
In the meantime I got my stainless steel coffee pot. It was truly beautiful, but using it at home revealed new aspects. It turned out not to be "drip free", however more important, the suspended tilting lid which opened and closed by the motion of pouring was smart, but it could not keep the coffee warm for more than an hour. That was a disappointing experience, when expecting to have a hot cup of coffee on an evening working late. The beautiful stainless cylinder together with the tilting lid was also the source of another problem. The relation between the base and the height of the steel cylinder made it rather unstable and easy to tilt, and then the tilting lid opened. With small children around my beautiful coffee pot became a dangerous trap, at least during the first hour when the coffee still was hot. So my beautiful stainless steel cylinder ended up in the closet, and the only time I use it now is when I tell this story to my students. I still, however, find Eric Magnussen’s coffee pot beautiful, but now with reservations. I do no longer find the design exemplary, at least I do not find it appropriate in the context of family life with small children or as a container for hot coffee to keep you awake when working late. Appropriateness, I have now learned is a more important aesthetic category than beauty, and a "pretty interface" is only so in an appropriate context.

But this talk is about ...
... pedagogical models (and reflections)

- Different ways of approaching technical materials in class.
- Mixing technology with other materials.
- Maximising outreach.
- Thinking about limitations.
People put platforms to use to learn and create things.
The same way we were teaching, other teachers decided to use this platform for STEAM teaching.
STEAM: Science Technology, Engineering, Arts, and Math
STEAM has taken off.

- Many public institutions in the field of education are using the so-called STEAM activities as a way to inspire the younger generations into pursuing science or technical studies.
- STEAM includes arts & crafts, creative technology, robotics, 3D printing, web programming, etc.
- Associated with it, pedagogical approaches such as PBL, constructionism, etc.
STEAM’s academic references.

- If you want to know more, you should read about Constructionism by Pappert, Resnick and others.
- You should also look at Freire and his theories around the pedagogy of the oppressed.
- Furthermore, you might want to explore aspects of group work (i.e. Social Constructivism), collaboration vs. cooperation, etc.
Case # 1: IBERCIVIS Foundation, Spain
WE CAME IN PEACE FOR ALL MANKIND

A recorded history of space exploration and the triumph of the lunar landing
Format

- Problem definition
- Call for applications
- Team selection
- Technical introduction
- Project building
- Launch
- Report
Main characteristics

- Informal education (some schools manage to bring it in)
- Off-the-shelf components, each team different
- Limited group size
- No theoretical component (there is, but it falls on the schools)
- Project Based Learning
- Complex logistics
- Duration: months, variable
Case # 2: Creative Technologies, Spain
//Declare the capacitive sensor:
CapacitiveSwitch sensor=CapacitiveSwitch(2,3);

void setup(){
  //initialize the capacitive sensor. Threshold is 400
  sensor.config(400);

  //initialize the servo motor
  pull.attach(9);
}

void loop(){
  if(sensor.getState()){  
    //If the capacitive sensor is touched, pull the stick
    pull.write(0);
BLOCK 1 - PROGRAMMING

Get started and learn the basics of programming. Develop an interactive snake, a video game or a customized clock using the programming environment Processing.

BLOCK 2 - SPORTS

Learn the basics of digital technologies to control digital actuators and read digital sensors. Build and play with small electronic games that simulate sports like basketball, fencing and pong among others.

BLOCK 3 - MAGIC

Learn about the magic of analog signals and the serial port. Build projects that introduce sound and images that highlight analog signals.

BLOCK 4 - ROBOTS

Learn the basics on how to control motors and sensors. Build different robots and add movement to them by using standard and continuous servos.
Format

Selection of schools

1 week teacher course

8 weeks / 4 areas of work

10 weeks project building

Exhibition

Report

2 weeks: Processing

2 weeks: Sensors

2 weeks: Actuators

2 weeks: Comms.
Main characteristics

● Co-designed with teachers at regional scale
● Specially designed kit
● Reached out to the whole of Spain after 5 years
● Project Based Learning
● Formal education
● No assessment mechanism provided
● Not every school is ready to replicate this (estimated 60%)
● The final goal has a big effect on the students
● Duration: months, fixed
Case # 3: PELARS, EU
(CREATE/CAPTURE) What new data analytics can be derived from the hands-on learning of STEM subjects?

(ANALYZE/REASON) How can these data analytics be used to understand and support practice-based learning?

(VISUALIZE) How can we develop visualization tools that combine learning analytics data from rich multi-modal sensors and students self-documentation to provide meaningful information?
Different use cases of Arduino Eslov

Mode 1: single sensor connected to PC via USB

Mode 1 bis: single sensor connected to smartphone via OTG connector

Mode 4: multiple sensors connected to each other via I2C, including battery module
Diagram of a generic Arduino Eslov block

- this diagram could also be applied to 'B'... just note, we cannot have use both on 'A' and 'B' at once!!

* or whatever time
LIGHT THEREMIN
Format

Introduction  Design brief  Project building  Exhibition
Main characteristics

- Experimental [research] setup
- Blended electronic materials with crafting ones
- Full classes would come to test
- No theoretical component, and no previous instruction
- Project Based Learning
- Duration: 1 hour to final result
Case # 4: Cardboard workshop, Malmö, Sweden
YOUR CAN BE:

- Arduino Micro
- Keyboard
- Mouse
YOUR FIRST BUTTON

AT A GALAXY FAR FAR AWAY...
corrugated cardboard

flex it (fold it)
in the center

copper tape

USB cable

some jumper wires

Arduino micro board

A computer
Format

Monday
Introduction to prototyping

Tuesday
Basic intro to Arduino
Program HID device
Basic intro to Scratch

Wednesday

Thursday
Project building

Friday
Exhibition
Main characteristics

- Blends low cost materials (considered a design quality)
- Off-the-shelf microcontroller boards
- Ran at the beginning of the education programme (thus no experience required)
- Project Based Learning
- Formal education
- Assessment: functioning project, presentation, participation in the module
- Duration: one week, fixed
Case # 5: Etopia KIDs, Zaragoza, Spain
Main characteristics

- Blends low cost materials (considered a design quality)
- Kit specifically designed for the occasion
- Summercamp
- Project Based Learning
- No assessment
- Duration: two weeks, fixed

Note: the kids kept the robots, since there were over 80 robots distributed, this had the side effect of creating a small community of roboticists that would meet monthly
Case # 6: Aguascalientes al Espacio, AGC, Mexico
Main characteristics

- Informal education (some schools manage to bring it in)
- Off-the-shelf components, all teams share a lab
- Limited group size
- Theoretical component from an external source
- Project Based Learning
- Complex logistics
- Duration: months, variable
What is the impact of the Arduino platform in teaching? Does it help students learn about embedded technology?
We got an opportunity through a third party.

- Electronic Cats is an SME based in Aguas Calientes, MX, dedicated to the design of small electronic products (hardware, firmware)
- Furthermore, EC design and implement experimental education experiences in STEAM for the regional government.
In this activity, EC created a remote farming laboratory, where the different schools could time-share a robotic farm where to grow vegetables. They simulating a future remote-farming scenario in a different planet.

For students and teachers to participate in this project they had to be introduced to a series of complex concepts in embedded technology, programming, design, building, etc.
Schools, teachers and students.

- This project reached out to a group of 14 schools in the region of Aguascalientes, MX.
- Each school joined the initiative with one team of 8 to 11 students.
- Students in the team would join by their own will, no selection mechanism was applied for the students (as a rule).
- It is likely that students adopted roles at the time of working with the project.
REPORTE SEMANA #19
No. 11 de 12
Capacitación de misión espacial del
23 al 26 de Mayo de 2022

DESCRIPTIÓN BREVE
Actividades desarrolladas semanalmente para el proyecto:
Aguascalientes al espacio 2022.
The learning process.

- Participating in the project implied participating in a series of lectures and events to introduce teachers and students to the materials.
- Teams were expected to conduct an experiment (all teams had access to the same tools), document it, and present it.
- The teams' progress was followed using rubrics.
<table>
<thead>
<tr>
<th>Porcentaje</th>
<th>ETAPA DE DESARROLLO</th>
</tr>
</thead>
<tbody>
<tr>
<td>5%</td>
<td>School team forming</td>
</tr>
<tr>
<td></td>
<td>Lectures with experts</td>
</tr>
<tr>
<td></td>
<td>Capacitación 1 &quot;Diseño Gráfico&quot;</td>
</tr>
<tr>
<td></td>
<td>Capacitación 2 &quot;Troya&quot;</td>
</tr>
<tr>
<td></td>
<td>Capacitación 3 &quot;Culo Satélite&quot;</td>
</tr>
<tr>
<td></td>
<td>Capacitación 4 &quot;Astrobotánica / Agricultura espacial&quot;</td>
</tr>
<tr>
<td></td>
<td>Capacitación 5 &quot;Administración y desarrollo de proyectos en tecnología&quot;</td>
</tr>
<tr>
<td>10%</td>
<td>Introduction for students</td>
</tr>
<tr>
<td></td>
<td>Encuentro de entrada</td>
</tr>
<tr>
<td></td>
<td>Capacitación en plataforma</td>
</tr>
<tr>
<td></td>
<td>Asignación de torres</td>
</tr>
<tr>
<td>15%</td>
<td>Land station</td>
</tr>
<tr>
<td></td>
<td>Capacitación en plataforma</td>
</tr>
<tr>
<td></td>
<td>Reconocimiento del kit</td>
</tr>
<tr>
<td></td>
<td>Interacción con plataforma Tiny Go</td>
</tr>
<tr>
<td></td>
<td>Programación de kit TEGO</td>
</tr>
<tr>
<td></td>
<td>Construcción de antena</td>
</tr>
<tr>
<td>15%</td>
<td>Laboratory on distance</td>
</tr>
<tr>
<td></td>
<td>Capacitación en plataforma</td>
</tr>
<tr>
<td></td>
<td>Asignación de tiempo</td>
</tr>
<tr>
<td></td>
<td>Conocimiento del laboratorio (analisis)</td>
</tr>
<tr>
<td></td>
<td>Control de robot teleoperado</td>
</tr>
<tr>
<td>15%</td>
<td>Astro-botanics</td>
</tr>
<tr>
<td></td>
<td>Sembrando (1ra oportunidad)</td>
</tr>
<tr>
<td></td>
<td>Sembrando (2da oportunidad)</td>
</tr>
<tr>
<td></td>
<td>Sembrando (3ra oportunidad)</td>
</tr>
<tr>
<td></td>
<td>Aplicación de abono</td>
</tr>
<tr>
<td></td>
<td>Mantenimiento a robot (Suspensión)</td>
</tr>
<tr>
<td></td>
<td>Recolección</td>
</tr>
<tr>
<td>5%</td>
<td>Data from pico-satellites</td>
</tr>
<tr>
<td></td>
<td>Reporte de misión lectura de datos</td>
</tr>
</tbody>
</table>

### Improvements

<table>
<thead>
<tr>
<th>Porcentaje</th>
<th>Mejora en actividades y gastos</th>
</tr>
</thead>
<tbody>
<tr>
<td>5%</td>
<td>On-capsule recording</td>
</tr>
<tr>
<td></td>
<td>Exiting survey</td>
</tr>
<tr>
<td>10%</td>
<td>Final report</td>
</tr>
<tr>
<td>5%</td>
<td>Presentación</td>
</tr>
<tr>
<td>5%</td>
<td>Technical demo</td>
</tr>
</tbody>
</table>
The survey process.

- Teacher Education
- Student Education
- Project Building
- Report and Presentation

First student survey
Second student survey
Our experiment.

- Great opportunity for us to measure the learning process by implementing a pre-post measuring point and to compare the knowledge on relevant concepts before and after the activity.
- Our goal is to determine whether this kind of STEAM activity can be considered as a good learning mechanism.
- In particular, whether it affects students' knowledge and competence in skills related to STEAM components.
Research questions

1. Does students’ **self-reported knowledge of STEAM tools** change after program implementation?

2. Does students’ **actual STEAM competence** change after program implementation?

3. Which STEAM skills improve more after program implementation?
Study design: Pre and Post STEAM program survey

- **Participants**: 47 students (16 females, 31 males)
- **Age**: 17 (16-19)
- **Stage**: Secondary school
- **Schools**: 14 different schools of Aguascalientes (Méjico)
- **Digital accessibility**: 100% reported access to Internet at home or via Smartphones and 92% reported access to a PC at home.
The STEAM survey: Structure

- Part 1_Consent form and Demography
- Part 2_Self-reported STEAM knowledge
- Part 3_Test of STEAM knowledge

---

- Two Phases: Pre and post
- Two versions: Students and Teachers
Self-reported STEAM knowledge

- Students rated their knowledge of 41 tools using a 3 point likert scale:
  
  \[0=\text{"I don't it, 1= I know it", 2= "I use it"}\]

- The 41 items were grouped in 9 categories.

- Scale reliability measured with Cronbach's alpha = .93 (p<.001).

<table>
<thead>
<tr>
<th>Categories</th>
<th>N_Items</th>
<th>STEAM component</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Handicraft tools</td>
<td>3</td>
<td>Technology, Art</td>
</tr>
<tr>
<td>2. Basic electronic</td>
<td>3</td>
<td>STEM</td>
</tr>
<tr>
<td>3. Digital literacy</td>
<td>2</td>
<td>Technology</td>
</tr>
<tr>
<td>4. Lab tools (9)</td>
<td>9</td>
<td>Technology, Art</td>
</tr>
<tr>
<td>5. Software (4)</td>
<td>4</td>
<td>Technology</td>
</tr>
<tr>
<td>6. Microcontroller in C (Arduino)</td>
<td>1</td>
<td>STEM</td>
</tr>
<tr>
<td>7. Microcontroller in Bloks (Microbit)</td>
<td>1</td>
<td>STEM</td>
</tr>
<tr>
<td>8. Graphic Design</td>
<td>7</td>
<td>Technology, Art</td>
</tr>
<tr>
<td>9. Presentation tools</td>
<td>11</td>
<td>Technology, Art</td>
</tr>
</tbody>
</table>
Self-reported STEAM knowledge

![Handicraft tools bar chart]

- Woodwork: Pre = , Post = , p = 0.02
- 3d_printer: Pre = , Post = , p = 0.02
- Laser cutter: Pre = , Post =
Self-reported STEAM knowledge

![Bar chart showing self-reported STEAM knowledge in basic electronics with statistical significance levels.](chart.png)
Self-reported STEAM knowledge

Digital literacy

<table>
<thead>
<tr>
<th></th>
<th>Internet skills</th>
<th>Computer skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre</td>
<td>1.50</td>
<td>1.00</td>
</tr>
<tr>
<td>Post</td>
<td>2.00</td>
<td>1.50</td>
</tr>
</tbody>
</table>

$p = .01$
Self-reported STEAM knowledge

**P-value <.01; * P-value <.05**
Self-reported STEAM knowledge

**P-value <.01; ** P-value <.05
Self-reported STEAM knowledge

**P-value <.01; ** P-value <.05
Self-reported STEAM knowledge

**P-value <.01; ** P-value <.05
Self-reported STEAM knowledge

**P-value <.01; ** P-value <.05
Test of STEAM competence

- Participants answered 19 multiple choice questions grouped in 3 categories:
- Measure: Percentage of correct answers per category

<table>
<thead>
<tr>
<th>Categories</th>
<th>N_Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Electronic</td>
<td>7</td>
</tr>
<tr>
<td>2. Robotic</td>
<td>7</td>
</tr>
<tr>
<td>3. Communication</td>
<td>5</td>
</tr>
</tbody>
</table>
Test of STEAM competence

- Participants answered 19 multiple choice questions grouped in 3 categories

Example of “Electronic” question:
Which electronic component converts electrical energy into heat?
1 = The electrical part
2 = The resistor (correct)
3 = The LED diode
Test of STEAM competence

**P-value < .01; ** P-value < .05
Conclusions & further work

- Does students' **self-reported knowledge of STEAM tools** change after program implementation?
  - Yes, students self-reported higher knowledge after

- Does students' **actual STEAM competence** change after program implementation?
  - Yes, students showed higher STEAM competence after

- Which STEAM skills improve more after program implementation?
  - Robotic and Communication
  - Is Electronics more difficult?, should be the program be improved to strengthen electronic?
  - How can “art” competence be measured?
Let's wrap this up in style.
Findings on Spaces
Spanish Maker Timeline

2000
First hackerspaces created
First hackmeeting in Barcelona
Medialab Madrid launches

2005
Reprap project launches
Arduino project launches
Fab: The Coming Revolution on Your Desktop is published
First Fablab Users Meeting (MIT)

2007
IaC launches Fablab Barcelona

2009
Interactivos 09, at Medialab-Prado, brings together several RepRap pioneers
Kernel Panic hacklab closes

1990
LAN Parties - Campus Party

2001
Institute of Advanced Architecture of Catalonia (IaC) launches

2006
Interhackerlab meeting in Madrid
Hangar launches its medialab in Barcelona
First Maker Faire in Bay Area
Second Fablab Users Meeting (Norway)

2008
Summer Lab, a meeting on experimental digital arts is launched by Laboral (Gijón)

2010
Rooted conference on cybersecurity launches
Barcamps emerge as meeting points for Arduino enthusiasts

2011
New institutional fablabs in Sevilla, Leon, Valencia, Asturias
Absolut lab launches and collapses in Madrid
Open Source Hardware Conference launches
Calafou, a self-defined post-capitalist ecoinformal colony, was born

2012
DARPA funds Maker Media to expand maker outreach

2013
First independent makerspaces launch in Madrid, Tenerife and Barcelona.
First mini maker faires appear in Bilbao and Barcelona

2014
New programs emerge to bring Technology, Programming and Robotics into the regular curriculum
Fab10, international fablab conference, is celebrated in Barcelona
HP launches 3D Printing factory in Sant Cugat (Barcelona)

2015
First regional fablab / makerspace events in Gijón and Ourense
New independent fablabs and institutional makerspace appear
NMC Horizon report includes makerspaces as a tool for schools in a 1-2 year timeframe

2018
City councils promote makerspaces and maker programs in libraries, education, etc.

2017
US Embassy and Ministry of Education host a conference at Medialab-Prado about Makerspaces in Libraries
Tradeshow opens maker areas or corners to promote STEM education
Aggregated new spaces per year

The plot of Running Sum of Count of Categoría secundaria for Fecha in 10 Year. Colors show details about Categoría secundaria. The names are labeled by Categoría secundaria. The data is filtered on Fecha in 10 Year and Categoría Principal. The Fecha in 10 Year filter keeps 12 members. The Categoría Principal filter keeps Aparturas. This view is filtered on Categoría secundaria, which includes 22 members.
Findings on Spaces
List of open questions to consider

- How do you deal with classes operating at multiple speeds?
- In the EU we follow an educational standard based on the Bloom's taxonomy (LOs), assessments, and class activities ... how about the rest of the world?
- Which are your expectations and how do those align with the ones from the students?
- Affordances ⇔ limitations, which are the ones you have detected?
- Repetition: is it acceptable to you? What about the innovation aspects?
- Online vs. Offline
List of open questions to consider

● Languages (not programming, but the other ones)
● Labs vs. personal kits: when and where?
● Kits vs. toolboxes: what is best?
● AI specific: dependency layers (C-NN-platforms)
● Guided vs. exploratory courses
● What is left when novelty has wear off?
There will always be people looking into creative uses of technology.
Thanks 🎓🎓 for coming by!