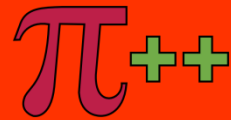


A lesson of Physical Computing with Scratch: RPi, scratchClient and Arduino

Presentation for Pi And More 10

Trier – 2017/06/24

Hans de Jong



Weekendschool



IMC
Weekendschool
Trudo
Weekendschool

- Generally parents tell their children: “Learn for later”. But what is later?
- “I want to become an engineer. Do you maybe know an engineer? I would very much like to meet one”

Weekendschool

Goal and way of working

- Bridge the gap between school and what is needed to live in society
 - Which is in more privileged families provided by the family
- Don't abandon them at the end: Alumni program
- Data shows: alumni have better professional prospects, are more self-aware, and feel more connected with society.
- Program includes training in presentation, research, debate, and conflict resolution – an allround character education.

Classes provided

- | | | |
|--------------|----------------------|-----------------|
| • Art | • Mathematics | • Entrepreneur |
| • Medicine | • Physics | • Safety |
| • Law | • Programming | • Energy |
| • Philosophy | • Electro | • Journalism |
| • Astronomy | • Film | • ... many more |
| • Politics | • Architecture | |
| | • Language & Poetry | |

Some numbers

- > 1000 students in 2016 between 10 and 14 years of age
- From disadvantaged neighbourhoods
- 3500+ volunteers
- Funded by 110+ sponsors (companies, individuals, foundations – not central government)
- Curriculum lasts for 2.5 to 3 years
- Over 2100 alumni
- Students are selected on motivation, not on IQ
- IMC Weekendschool was founded in 1998, Trudo Weekendschool in 2009
- IMC Weekendschool has inspired 30+ other independent copy projects in The Netherlands (one of which is the Trudo Weekendschool).

More information

- www.imcweekendschool.nl
- www.trudoweekendschool.nl

Curriculum of Programming

Objectives

- Learn how to use keyboard, mouse and screen without causing health problems.
- Learn how to make programs in Scratch
- Learn that programming is about more than changing pixels on a screen, so also do Physical Programming.
- Learn something about professional programming.
- Build something tangible that can be taken home.
- Let the children experience how powerful and joyful programming is.

3 - 5 Weekendschool days

- Each is 2x 75 minutes with 30 minutes lunch break inbetween
- 3 days given to Weekendschool 2nd graders: 11 years old.
- 2 days given to Weekendschool 3rd graders: 12 years old.

The 3 lessons of the curriculum

Lesson 1 (day 1 and part of 2)



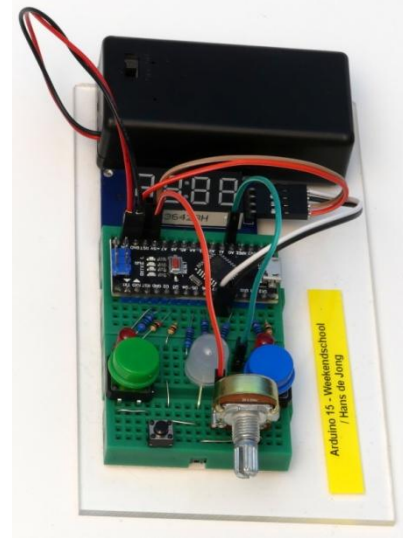
- Program a game in Scratch, output on monitor.
- 1 helper per 4 to 8 students.
- Max. 60 students per class.

Lesson 2 (part of day 2 and day 3)



- Physical computing controlled from Scratch.
- 1 helper per 4 students.
- Max. 60 students per class.

Lesson 3 (day 4 and 5)



- Program an Arduino Nano from RPi.
- Build the electronic circuit of a game to be able to take it home.
- 1 helper per 2 students.
- Max. 30 students per class.

9 Volt power
(power of Raspberry Pi is too limited, and cheap microUSB cables cannot transport high current)

Arduino Nano with
328p processor

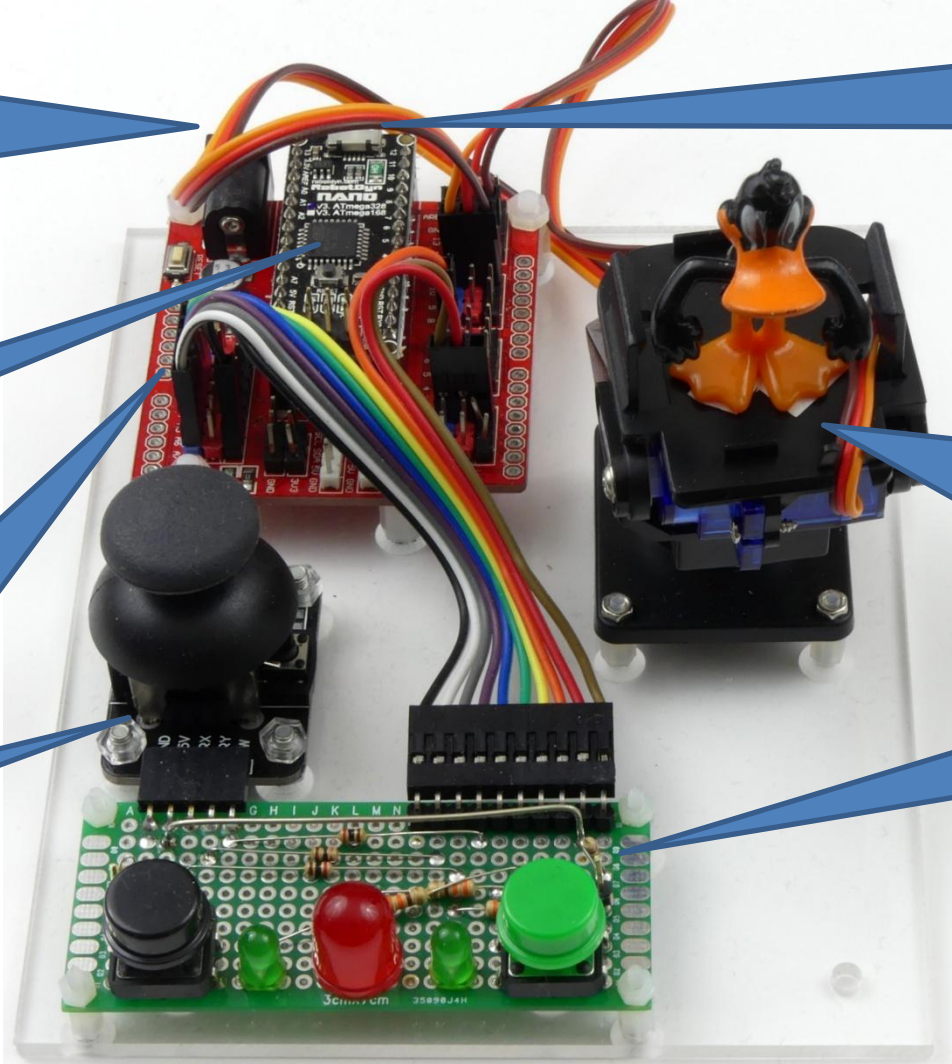
Extension board
(handy connections with 3 pins per GPIO (VCC, GND and signal) to connect servos, power regulator)

Joystick to
demonstrate analog
input

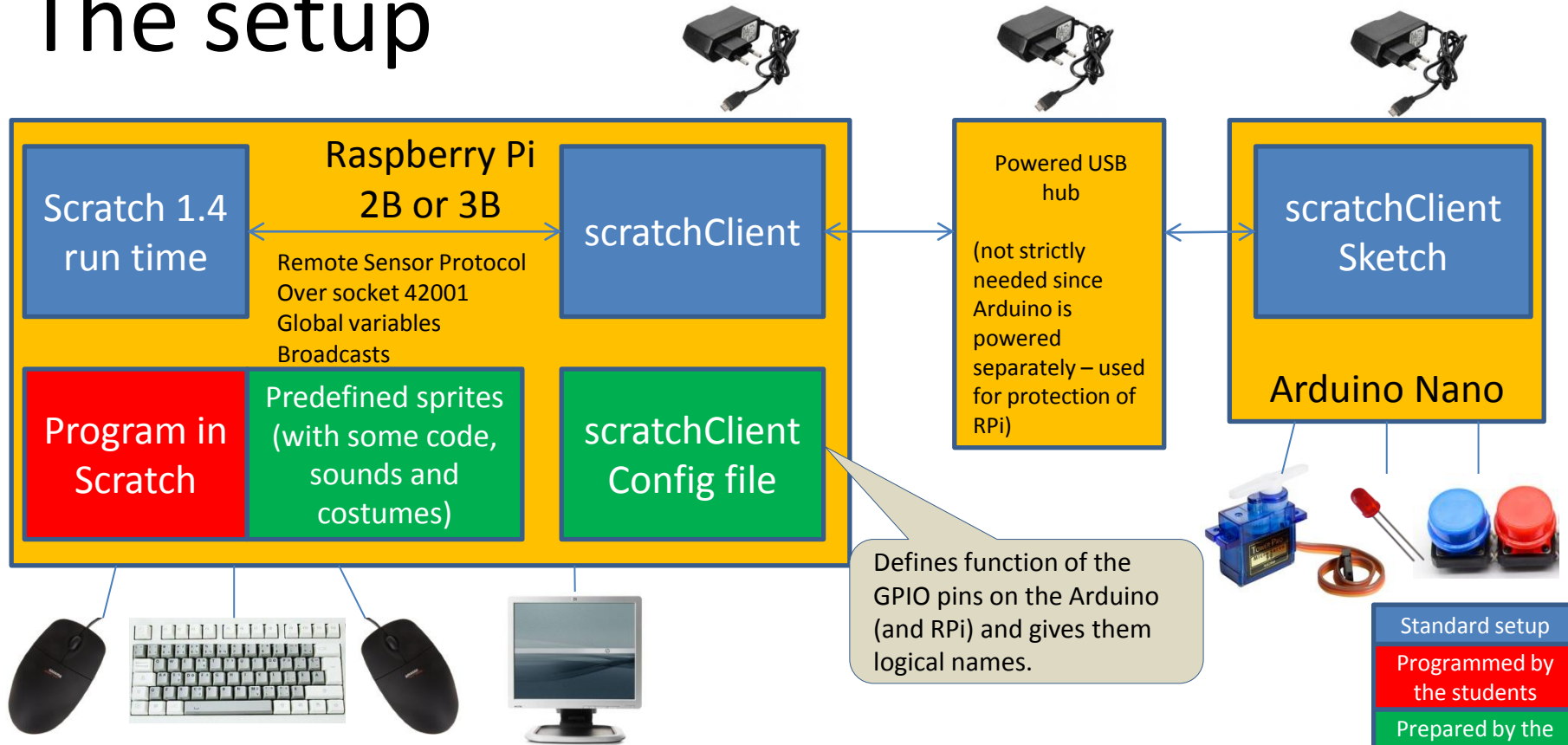
USB connection to
Raspberry Pi
(optionally via a
powered USB Hub)

Duck on a pan/tilt
platform to
demonstrate the
use of servos


Buttons and LEDs to
demonstrate digital
input / output



The setup



The game

- Start the game by pressing the joy stick button (because it is there anyway)
- Red LED lites at random 
- When LED lites, the first one pressing their button gets a point
 - The duck turns to the person scoring and makes a bow.
- When the button is pressed without the LED being lit, the other gets a point
 - The duck turns to the one who pressed and shakes “no”.



Demo of the game

Have a look at

<https://www.youtube.com/watch?v=Qo1gnXNzhqE>

Why using an Arduino* for GPIO rather than the GPIO of Raspberry Pi?

- Arduino provides analog inputs.
- Arduino provides *hardware* PWM (Pulse Width Modulation), which makes controlling servos more stable.
- Arduino can support real time protocols (e.g. for controlling WS2812).
- Arduino GPIO pins are 5V tolerant.
- When making mistakes, blowing up an Arduino Nano is less costly (< 2.5 euro for a clone) than damaging a Raspberry Pi.
- When needing more GPIO pins, extra Arduinos can be added.
 - scratchClient supports this as beta.
- Easier setup and tear down in temporary classroom situations
 - Only needing to plug/unplug USB and power connectors.
 - Can be programmed to steer servos automatically to default position, ready for packing up.

* Arduino Nano or Arduino Uno can be used

scratchClient: things to know

Installing

- Download scratchClient
 - http://heppg.de/ikg/wordpress/?page_id=6
- Unpack
- Install other packages as described on the download page
- Adapt the config file for Arduino Uno (which is used for Nano as well)
 - NEW: A good UI is now available, so now very easy to do.
- Use the Arduino IDE to program the scratchClient sketch in the Arduino
 - Note: I have experienced problems when loading sketches via a USB hub. Works fine without.

Using

- Start scratchClient with the correct config file as parameter.

Help?

- Everything is described in the excellent documentation.

Cost and effort for the board

- See Bill of Material on the next slide.
- Material cost for a single piece: ca. **20 euro**, but you will get spare material for that amount.
- Material cost for a series for e.g. a school: can get **sub 20 euro**.
- Labour content (no compensation included in the cost): **ca. 2.5 hour**.
- Most components were ordered from Aliexpress.com.
 - Benefits
 - Extremely low prices.
 - Almost always shipped for free to The Netherlands, Germany and probably other EU countries.
 - Counterintuitive: the **smaller** the order, the more chance that there are no shipment costs.
 - Disadvantage
 - Never any data sheet and hardly ever precise specs.
 - So you will need to Google and find other sources. And sometimes just buy and try.
 - Delivery takes between 2 weeks and 2 months
 - Or arrives never (some 2% of shipments), but then refund is promptly provided.
 - Especially for power supplies: do not expect more than 50% of output current that is rated.
 - Otherwise it will overheat and blow up. Or the voltage drops way below what is needed.
 - Occasionally products are quickly running out
 - So make sure you order quickly the amount you need and some spare for the future.
 - Note: limit each order to max 22 euro (holds for all of the EU) if you want to avoid VAT, import duties and handling costs at the shipping company.
 - Secure payment possible (at least in The Netherlands: you can use IDEAL).

BoM (Bill of Material)

What	Where	Cost (euro) Free @ dec 2016 shipm.	#	Total cost	Remarks	Link
Pan / tilt platform	Aliexpress	0,37 Y	1	0,370		https://www.aliexpress.com/item/Hot-Sale-PT-Pan-Tilt-for-Aircraft-FPV-Dedicated-Nylon-PTZ-20g-for-9G/32318408962.html?spm=2114.01010208.3.17.emGyl4&ws_ab_test=searchweb0_0,searchweb201602_1_11
SG90 servo	Aliexpress	1,12 Y	2	2,240		https://www.aliexpress.com/item/Free-Shipping-1PCS-LOT-SG90-9g-Mini-Micro-Servo-for-RC-for-RC-250-450-Helicopter/32246798112.html?spm=2114.01010208.3.19.2QRJMH&ws_ab_test=searchweb0_0,searchweb201602_1_11
Duck	Aliexpress	0,23 Y	1	0,229	Sold per 40. Now sold out	
Arduino nano	Aliexpress	2,31 Y	1	2,310		https://www.aliexpress.com/item/Nano-CH340-ATmega328P-MicroUSB-Compatible-for-Arduino-Nano-V3-0/32572612009.html?spm=2114.13010608.0.0.4jDta
Nano expansion board	Aliexpress	1,51 Y	1	1,510		https://www.aliexpress.com/item/FreeShipping-NANO-and-UNO-multi-purpose-expansion-board-FOR-ARDUINO/1803703524.html?spm=2114.13010608.0.0.Yif9mN
Joy stick	Aliexpress	0,47 Y	1	0,470		https://www.aliexpress.com/item/Free-Shipping-Higher-Quality-Dual-axis-XY-Joystick-Module-PS2-Joystick-Control-Lever-Sensor-for-arduino/32280675624.html?spm=2114.13010608.0.0.Ck50On
9V power supply	Aliexpress	1,69 Y	1	1,690		https://www.aliexpress.com/item/ALLSHOP-9v-1a-dc-power-adapter-eu-5-5mm-2-1mm-interface-Power-Supply-100-240v/32774734258.html?spm=2114.01010208.3.1.3cRB4l&ws_ab_test=searchweb0_0,searchweb201602_1_11
Buttons	Aliexpress	Y	2	0,380	price is for 10. Note 3.	https://www.aliexpress.com/item/New-10-x-Tactile-Push-Button-Switch-Momentary-6x6x4mm/32307209787.html?spm=2114.01010208.3.1.aeQg3l&ws_ab_test=searchweb0_0,searchweb201602_1_11
Red LED 10 mm	Aliexpress	Y	1	0,930	price is for 10. Note 4.	https://www.aliexpress.com/item/10mm-Red-LED-Round-Light-Emitting-Diode-Transparent-Ultra-Bright-Lamp-Bead-Plug-in-DIY-Ki/32679401247.html?spm=2114.01010208.3.193.qG0xVG&ws_ab_test=searchweb0_0,searchweb201602_1_11
Green LED 5 mm	Aliexpress	Y	2	0,570	price is for 10. Note 4.	https://www.aliexpress.com/item/5mm-LED-Emerald-Green-Diffused-Round-Light-Emitting-Diodes-Lamp-Bead-DIP-Plug-in-Through-Hole/32671838043.html?spm=2114.01010208.3.96.O8nPPQ&ws_ab_test=searchweb0_0,searchweb201602_1_11
Right angle connector - 10 pins	Aliexpress	Y	1	0,890	price is for 10x40 pins	https://www.aliexpress.com/item/DSHA-New-Hot-10-Pcs-1-x-40-Pin-2-54mm-Pitch-Single-Row-Right-Angle/32701451750.html?spm=2114.01010208.3.1.8WkxAO&ws_ab_test=searchweb0_0,searchweb201602_1_11
Dupont shell 10 pins	Aliexpress	Y	1	0,023	Note 1	https://www.aliexpress.com/item/50Pcs-2-54mm-10P-Pitch-Dupont-Jumper-Wire-Cable-Housing-Female-Pin-Connector-Dupont-Plastic-Shell/32584850092.html?spm=2114.13010608.0.0.9DOqGf
Dupont shell 6 pins	Aliexpress	Y	1	0,022	Note 1	https://www.aliexpress.com/item/50Pcs-2-54mm-6Pin-6P-Dupont-Connector-Dupont-Plastic-Shell-Plug-Dupont-Housing-Pin-Header/32325424414.html?spm=2114.13010608.0.0.9DOqGf
Dupont shell 3 pins	Aliexpress	Y	1	0,018	Note 1	https://www.aliexpress.com/item/50Pcs-2-54mm-3pin-3P-Pitch-Dupont-Plastic-Shell-Head-Plug-Dupont-Housing-Pin-Header-Jumper/32451135789.html?spm=2114.13010608.0.0.59zctI
Dupont wire 10 cm F/F	Aliexpress	0,64 Y	1	0,640	only 1/4 needed	https://www.aliexpress.com/item/40pcs-lot-10cm-2-54mm-1pin-feMale-to-feMale-jumper-wire-Dupont-cable/32226515120.html?spm=2114.13010608.0.0.oxao9B
USB cable microUSB 1 meter	Aliexpress	0,48 Y	1	0,480		https://www.aliexpress.com/item/New-1m-3FT-Micro-USB-Charger-Charging-Sync-Data-Cable-for-Samsung-Galaxy-S3-S4-S5/3257939998.html?spm=2114.13010608.0.0.160S22
180 ohm resistor. 1/4 W	Aliexpress	Y	3	0,570	price is for 100.	https://www.aliexpress.com/item/Free-Shipping-100pcs-180-ohm-1-4W-180R-Metal-Film-Resistor-180ohm-0-25W-1-ROHS/32481576565.html?spm=2114.01010208.3.166.LP8VW4&ws_ab_test=searchweb0_0,searchweb201602_1_11
1 kohm resistor. 1/4 W	Aliexpress	Y	3	0,570	price is for 100.	https://www.aliexpress.com/item/Free-Shipping-100pcs-1k-ohm-1-4W-1k-Metal-Film-Resistor-1kohm-0-25W-1-ROHS/32479506254.html?spm=2114.01010208.3.11.gE5Cq&ws_ab_test=searchweb0_0,searchweb201602_1_11
Perspex base plate 11x14 cm	Kunststofplatenshop.nl	N	1	0,640	Note 2	https://kunststofplatenshop.nl/product/plexiglas-helder-3-mm/
PCB board 3x7	Aliexpress	0,64 Y	1	0,640	Note 5	https://www.aliexpress.com/item/Free-Shipping-1set-5x7-4x6-3x7-2x8-cm-double-Side-Copper-prototype-pcb-Universal-Board-for/32278906575.html?spm=2114.01010208.3.1.8bN4H2&ws_ab_test=searchweb0_0,searchweb201602_1_11
spacers M2	Aliexpress	Y	8	0,765		https://www.aliexpress.com/item/25-Pcs-Nylon-Standoff-Spacer-M2-Male-x-M2-Female-5mm/32365215325.html?spm=2114.01010208.3.64.vrsL3B&ws_ab_test=searchweb0_0,searchweb201602_1_11
spacers M3	Aliexpress	Y	8	0,970		https://www.aliexpress.com/item/Wholesale-25-pcs-set-Cheapest-Universal-Black-Nylon-Standoff-Spacer-M3-Male-x-M3-Female-6mm/32603041166.html?spm=2114.01010208.3.33.CmgC9&ws_ab_test=searchweb0_0,searchweb201602_1_11
nuts M2	Aliexpress	Y	8	0,840	price is for 50.	https://www.aliexpress.com/item/50Pcs-lot-M2-Nuts-2mm-Screw-Nut-Hexagon-Nut-Match-Copper-Cylinder-for-Robots-Good-Quality/32725587632.html?spm=2114.01010208.3.1.Uv2HoY&ws_ab_test=searchweb0_0,searchweb201602_1_11
nuts M3	Aliexpress	Y	8	0,730	price is for 50.	https://www.aliexpress.com/item/20Pcs-lot-M3-Screw-Nut-Hexagon-Nut-Match-M3-Copper-Cylinder-3mm/32659135845.html?spm=2114.01010208.3.55.uIC37p&ws_ab_test=searchweb0_0,searchweb201602_1_11
countersunk screws M2 x 5	Aliexpress	Y	8	1,500	price is for 100.	https://www.aliexpress.com/item/70pcs-M2-black-countersunk-head-machine-screws-Flat-head-machine-screw-mechanical-screw-s8/32595913794.html?spm=2114.01010208.3.56.uwwGJE&ws_ab_test=searchweb0_0,searchweb201602_1_11
countersunk screws M3 x 5	Aliexpress	Y	8	1,200	price is for 100.	https://www.aliexpress.com/item/M3-x-5mm-Cross-Flat-Head-Countersunk-Bolts-Machine-Screws-100Pcs/32759862916.html?spm=2114.01010208.3.59.9gydYl&ws_ab_test=searchweb0_0,searchweb201602_1_11
Powered USB hub	Elektronika Online	N	1	2,000	Not strictly needed. Note 6	http://www.elektronika-online.nl/
Not calculated: soldering tin						
Total				23,20		
Note 1	Dupont shells are not strictly needed when building a few pieces. Cost is taken at the item price when ordering 50 or 100					
Note 2	The cost is when ordering minimally 10 euro. On top there is 14 euro shipping cost. However it is not strictly needed for building single pieces. You could use a piece of cardboard, MDF etc.					
Note 3	Not the same as in the setup. Those are 8,26 euro / 100					
Note 4	Costs are lower when ordering more					
Note 5	This is the cheapest to get a single piece. Better price is 2,34 euro / 10					
Note 6	Running out. Free shipment (in The Netherlands) above 100 euro					

The URLs are in the Excel file on github. See slide 16.

What can scratchClient do?

- Control pins on Arduino Uno / Nano for Digital In, Digital Out, Analog In, PWM (Pulse Width Modulation).
 - NEW: Counter function (counting pulses from e.g. IR speed detector)
- As well control all the GPIO pins on Raspberry Pi.
 - NEW: Control Sonic Pi, Minecraft, MQTT, Scroll Phat HD, Micro Dot Phat, Lirc IR remote controls
- Allow peripherals be addressed by comprehensible names rather than pin numbers.
- Run on a Windows PC and in combination with Arduino provide physical computing to Scratch running on Windows.
- Monitor the hardware state from a browser, simulate hardware signals in the browser.
- Monitor hardware state of all workplaces from a central Windows PC.
- Allows to use predefined configurations for experiments, which makes setup in a classroom very easy.
 - Minimizing the trouble with I/O configuration.
- Keep apart multiple connected Arduinos and address the right GPIO pins on the correct Nano
 - So the number of connectable peripherals is virtually infinite.

→ My conclusion:

scratchClient is the ideal software to bring physical computing to Scratch!

Announcement ...

- Within a few weeks, scratchClient will also support Scratch 2
 - In addition to Scratch 1.4
- Scratch 2 runs via a browser on Windows PC or RPi
 - So not stand alone

Try for yourself?

- Attend my **beginners** workshop at **13.30** today and/or the **advanced** workshop at **16.00**
 - You can there try it out for yourself (2 people per workplace setup)
 - Please drop by in the workshop room HZ203 to register
 - Space is limited.
- Workshop will be in English (presentation, material, support)
- There will be German spoken support in addition to English
 - Gerhard Hepp, author of scratchClient, will be present.
- You will learn how to configure scratchClient, control hardware from Scratch, build up a test board and – if you want – take a look at the game.
 - See the program flyer or ask me after the presentation for more information.

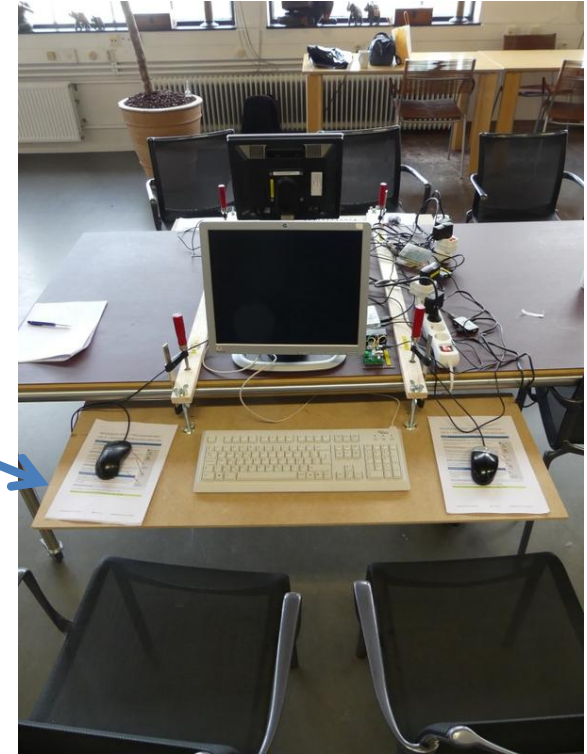
More information

- This presentation, source files of the game and workshop material
 - www.github.com and search for *Weekendschool* or for *PiAndMore*
- scratchClient
 - http://heppg.de/ikg/wordpress/?page_id=6
- Scratch
 - <https://scratch.mit.edu/>
- Scratch on Raspberry Pi
 - <https://www.raspberrypi.org/forums/viewforum.php?f=77>
- Raspberry Pi
 - <https://www.raspberrypi.org/>
- Arduino
 - <https://www.arduino.cc/>

Making a workplace for 2 students

- Raspberry Pi 3B
 - With power supply
 - With 16 GB microSD card
- Second hand monitor HP1750 or HP1740
- Second hand keyboard
- Second hand mice (2x)
 - so students can each use a mouse and can be instructed: learn to use your left hand for the mouse as well.
- MDF 9 mm board (better: 2x 4 mm with 12 mm filler in between)
 - See further the pictures
- For 2 workplaces opposite of each other: 2 laths, 4 clamps, 4 threaded rods M8, 4 nuts, 16 large washers, 12 butterfly nuts.
- 84 liter crates of RUB (Really Useful Boxes) can very precisely contain 4 monitors
 - 2 monitors dismounted from their pedestal
 - Can in addition hold mice and cables.
 - <http://www.reallyusefulproducts.co.uk/>

Ergonomics:
keyboard at the
correct height to
teach children
to pay attention
to how they sit
when using
computers to
avoid medical
problems (RSI)
later in life.



Questions?