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**Current status of curricular considerations**

This is just a sampler of impressions, experiences and comments by participants and associates.

These considerations are basing on *Non Formal Learning Environment* (elective subjects and courses) performed by a group of approximately 8 students in 4 teams with one weekly lesson of 90-120 minutes.

Material considerations:

- LEGO®-Mindstorms Education EV3 is quite expensive (470 € new, ~300 € second hand) to buy, but

- it seems to save a lot of money in questions of destruction (normally no misconnection possible)

- it saves a lot of time concerning preparation by the instructors (students start directly with the box)

- it allows controlling the completion of material within 30 min by checklist

- rechargable battery is included, just a charger (10 €) is necessary

- it does not need more than 42,5 cm x 31 cm x 15 cm for one durable well structured box

(A large ready construction needs further 42,5 cm x 31 cm x 30 cm for storage, but that´s it.)

LEGO®-Mindstorms Education EV3

- is integrating construction *and* programming competencies as well

(Nonetheless an instructor is free to offer ready built objects, if just programming is the goal.)

- basing on well structured modular parts

- almost no tools necessary

- sufficient precision for models beneath the level of engineering

- offers reliable step by step construction manuals integrated in the software

- offers a simple graphical programming-system – almost no reading competencies necessary!

- works bidirectional:   
 triggers actors and shows connection and current status of sensors and actors on screen of PC/Laptop

- allows to integrate individual sound, text and graphic-creations

- with minimal help by a course instructor children from 6 years on seem to be able to start

- the tasks are possible to become differenciated in modular jobs

- the difficulty may increase up to education of engineers in their second year at university

- higher languages may be used, like SCRATCH or PYTHON or… C+

- OpenRoberta can be used by additional firmware (using micro-SD slot), offering simulation as well

- above the preformed construction tasks and ready to use programs modifications are possible

- Existing LEGO®-technic bricks and beams are still useable

Although the material offers tasks for hundreds of lessons and opens a world for own ideas for thousands of hours, we must accept, that young students should experience a lot of different courses in different subjects during 4 years.

In case of semester-related competing offers in sports, music, arts, technics, literature etc. the students could (should) choose 8 different courses from the 5th up to the 8th form. A school should push the students, to choose different courses, in order to open their eyes for lifetime open minded attitude.

Although this postulate, students have been recruited for 2 years in this project, in order to study basics, experience different material and cooperate with foreign students all over Europe. A contradiction? Not really! Indispensible components from the conditions of the ERASMUS+ Program are mobility, visits and hospitality, cultural, sportive and regional studies up to cooking, having meals and festivities together. This means, ERASMUS+ projects integrate different offers from school´s usual range of services.

Nevertheless a „normal“ course in basical *ICT-ROBOTICs-ETHICs* should not last longer than half a year.

This is following the comment of one of our participants, who – although quite bright in constructing and programming – is beginning to feel bored after half a year, particularly since he seems to pretend, that he was misunderstanding the conditions of duration in participation in the project. Nevertheless his opinion shall be respectfully summarized at this place: ½ year intensive course using graphical language offers enough basics. Extending contents might be offered separately. During 4 years 8 different additive courses should be available for children.

So, how to structure ½ year with approximately 20 weeks of about 90 minutes per session?

**01 Unboxing, Connecting Charger, Assorting Parts, Starting Software, Checking Sensors and Actors**

- Try 1st Program with *Wait for Touch of Switch* and *Run Large Motor for 5 seconds*.

- Try 2nd Program with *Wait for Colour Red* and *Run Medium Motor for 3 Circles*.

- Try 3rd Program with *Wait for Distance less than 10 cm* and *cause sound of a barking dog*.

- Try 4th Program with *Wait for Distance more than 10 cm* and *show GO on the Display*.

**02 Follow** **LEGO®-MINDSTORMS EV 3 Software for Vehicle-Assemblage** independently in **46 steps**!

- Keep material well organized for quick success!

- Prevent connector of BrainBrick against damage; install a 90°-cable permanently!

**03 Programming of Robot-Vehicle**

- Drive the robot-vehicle a dedicated distance!

- Stop in front of a barrier!

- Stop at dedicated colour!

- Make noise when stopping!

**04 Let´s dance!**

- Drive the robot-vehicle a dedicated trace.

- The robot-vehicle is dancing special steps.

- The robot-vehicle reacts on colours.

**05 Looping?**

- RED traffic-light; Robot-vehicle stops.

- … on YELLOW roaring motor noise.

- … starts on GREEN traffic-light.

- Loop is necessary, otherwise restart of program after every stop

**06 Managment for Lego® - Projects and implemented Programs**

- How to **downlod** a **PROJECT**

- How to **mangage PROJECTS and PROGRAM-files in the PC**

**Changefolder** vs **Personal Folder**

- how to **manage** **PROJECTS** and **PROGRAM-files** in the **BrainBrick**

**Teacher´s robot welcomes participants:**

“Hello, Yessi!”, “Hello, Vladimir!”, “Hello, Rita!”, “Hello…!”

WelcomeParade may be a **Download-Example**.

It may become tried out, modified with own soundfiles.

or

programmed with **LEGO®-MINDSTORMS EV 3 Software** from the beginninglike **self-developed.**

The teams may **assemble** the **gripper** onto the Robot-Vehicle and try to **program** its **function.**

Discuss Dis-/Advantages or job-consequences for employees and clients in nursing services!

**07 Have you got own ideas? I**nvent**, C**onstruct, **A**ssemble, **P**rogramme, **T**est, **R**efine

- Temperature related [Fan](http://www.ict-robotic-ethic.de/index_htm_files/20191024%20FanTemp.mp4) (needs additional Temperature Sensor!)

- Robot stops in a [certain area](http://www.ict-robotic-ethic.de/index_htm_files/20191024%20StopDistance.mp4); 10 trials

- Robot stops at [RED](http://www.ict-robotic-ethic.de/index_htm_files/20191024%20StopRED.mp4)

- Let the robot wink with the fork

- Robot as a barking [Guard Dog](http://www.ict-robotic-ethic.de/index_htm_files/20191024%20Guarddog.mp4)

Each team refers progress, obstacles and solutions to the others.  
 Discuss Dis-/Advantages or job-consequences for security guards and watch-dogs!

**08 If-clause** in a program needs a **Switch!**

- **Linefollower** (how and where to mount the sensor; how to adjust velocity of adaptation?)

Alternatives: Extraordinary Experiments with additional Sensors (available differentiation):

- **On the route** (defined trace)

- **Robot-Musician** (Melodie from Brainbrick)

**- Refugee** (Robot rolls away, when it´s warmer than 32°C.)

**- Noise-Sensor** (Basics, Clap-Switch)

**09 Create a Key by Code** and **Explore the Display**

**- ColourKeyCode can**

- starta **motor** (triggering noise from BrainBrick)

- trigger a **fork-movement**

- open a **bar**

- **unlock** a door etc.

**-** Fan uses Temperature-, Colour- **and** Soundsensor for a serial code sequence

- **Display can** show

- text

- signs

- individual graphics

**10 Robot-Vehicle for Parcel-Service**

- Robot recognises colour of a parcel  
 - Bar is going down  
 - Robot is pulling/pushing the parcel to a defined adress

Discuss Dis-/Advantages or job-consequences for employees and customers in parcel services!

**11 Our Robot is organizing coloured boxes automatically**

- Assembling the Coloursorter following the LEGO®-Software

- [Fill/ Recognize](http://www.ict-robotic-ethic.de/index_htm_files/20200109%20Col%20Sort%20Fill.mp4) Colours; [Sort](http://www.ict-robotic-ethic.de/index_htm_files/20200109%20Colo%20Sort%20work.mp4), following the Array-Structure of the original LEGO®-Program

**Additional Differentiaton for Christmas**

- Music-Device**(Jingle Bells)**

Discuss Dis-/Advantages or job-consequences for employees in ware-houses!

**12 Modification of Colour-Sorter in Construction and Programme**

- Place the Colour-Sensor above the edge of the ramp, where the boxes leave the shutter

- Create a programme ***without arrays***, just using integrated switches in a loop

- If possible, add comments concerning the function of program-steps.

Discuss Dis-/Advantages or job-consequences for employees and customers in ware-houses!

**13 Robot-Arm**

- Assembling the Robot-Arm following the LEGO®-Software

- Try the Robot-Arm, following the original LEGO®-Program

**Additional Differentiaton** by **individual** **constructions** or **modifications 🡪 14**

Discuss Dis-/Advantages or job-consequences for employees in industrial production!

**14 – 15 Engineers improve, integrate and innovate inventions**

- **Forklift**  
 Some different constructions with content of the box or additional parts.  
 Try out lift´s positions by using the Block-Execution step by step.  
 Add emergency-stop-switches.

- **LineFollower** **Keep distance** by stops; using Ultrasonic-Sensor  
 **Adapt velocity** by Cruise-Control; using BrainBrick´s Control Buttons

**Driverless car adapts velocity** to a slower one, using **variable SPEED**, **data-store** and **-transfer**

Discuss Dis-/Advantages (Safety, Comfort, Reliability) in public traffic!

- **Robot-Arm**  Write your own program for the Robot-Arm  
 Modify the Robot-Arm with Remote and IR Sensor  
 Modify the Robot-Arm with position of coloursensor at the gripper  
 Install automatical recognition of brick´s colour; shifting bricks to colour-related destinations.

Discuss Dis-/Advantages or job-consequences for employees in industrial production!  
Discuss Dis-/Advantages or job-consequences for employees and clients in nursing services!

- Individual **Display Design**Discuss Dis-/Advantages or job-consequences for employees and clients in super-markets!

**16 – 17 Sequential activities of Robots, Interaction of Robots, Relation between Robots**

**Robot Arm puts empty Coloured Containers from A to B or C   
 Vehicle transports empty Coloured Containers towards the Colour-Sorter  
 Colour Sorter is spitting coloured Bricks into the coloured Containers**

**18 – 19 Finishing Reports by Comments on Modified Constructions and on Programs**

**Videos like Paycheck or ExMachina as trigger for Discussions concerning Ethics**

**20 Demonstration for parents-evening, course-advertisement for interested or potential students.**

Regardless our preference for LEGO®-Mindstorms Education EV3, we have to point out, that under other preconditions than those we decsribed, other systems would be preferable.

The aspects of saving money, preference of just programming exercise and less construction tasks, advanced competencies in free construction with non preformed material, type of school, age of students etc. might cause specific decisions of students, parents and teachers concerning material or programming platforms.

Thus we try to offer an overview around some systems and platforms, we got in contact with during our project, by the following chart:

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| System | costs | challenge | ready  to use? | dimen-sional  accuracy | storage system | Adressees  or age  of users | con-structing | pro-  gramming | success | differen-tiation |
|  | … €  expensive  balanced  cheap | too difficult  too simple  easy  motivating  adequate | no  almost  yes | perfect  sufficient for…  poor | perfect  good  usable  chaotic  missing | preschool  4 – 6  primary school  6 – 10  secondary  10 – 18  voluntary  16 - 20  university  18 - … | no  just assemb-ling  yes | no  yes  system  language | instantly  quickly  needs patience | narrow  possible  wide  modular |
| ARDUINO® | Cheap ~22€ | depending on task | Moduls ~ 20€ extra | sufficient | small  box | voluntary  16 - 20 | challenging | Yes  C+ | needs patience | possible |
| CALLIOPE® | cheap | easy,  except file  storage | yes,  start-program  loaded | almost nothing to assemble  at the start | nice,  small  box | 6 – 60 | no | NEPO like  SCRATCH,  PYTHON,  JAVA | quickly | wide by individual tasks |
| CALLI:bot®  by knotech® | cheap | depending on task | just assemble 10 min;   well guided | perfect | Ecol. +  card  board  box, but  too small for assem-bled car | 6 – 60 | not really; electronical/ mechanical extensions need specific knowledge | yes  NEPO like  SCRATCH | quickly | wide by individual tasks |
| Cozmo® | expensive | starts  playing | yes | ./. | perfect | 8 – 12 | no | Colourkeys  almost no  technical  sense; just game | quickly | almost no  technical  sense;  just game |
| FESTO® | expensive | Vocational  Profes-sional | profes-sional assem-bling is part of the job | industrial  durable quality | profes-sional | vocational school,  university | from  model up to engineer  tasks | SPS\* | doubt-less because of selected users | quite special  adressees  depending on jobs |
| fischer technic® | balanced in relation to quality | adequate | Yes, but  needs to buy compo-nents, power, software | really good, almost industrial | missing;  needs to be bought  extra | Construc  -ting  **and** program-ming  10 – 80 | yes | Logic Flow-Chart  SPS\* | quickly,  depends on the tasks | wide by individual programs |
| micro:bit® | one of the cheapest | easy,  except file  storage | yes,  start-program  loaded |  | nice,  small  box | 6 – 60 | no | NEPO like  SCRATCH,  PYTHON,  MakeCode | quickly | wide by individual tasks |
| micro:rover® | cheap | depending on task | just assemble 10 min | perfect | Ecol. +  card  board  box, but  too small for assem-bled car | 6 – 60 | Not really; electronical/ mechanical extensions need specific knowledge | yes  MakeCode  Python  C++ | quickly | wide by individual tasks |
| LEGO® mindstorms  EV3 EDUCATION  EV-G graphical blocks will be kept also in LEGO®CLASSROOM from spring 2020 on, wrote Chris in LEGO®  CHAT 20200330 | 470€ new  300€ used  balanced in relation to practical-ness | adequate by differen-tiation | ~ 10 €  charger  needed or e.g. home version 31313 needs  6 AA Cells | sufficient  for school | quite  good | from playing,  to contructing **and** program-ming  6 – 90 | yes perfectly guided  or individual | simple graphics;  almost without reading  up to Scratch  and higher | quickly,  depends on the tasks | wide by modular jobs and individual programs |
| RASPBERRY® PI Micro-Computer | cheap  ~40€ | depending on task | moduls ~ 40€ extra | sufficient | small  box | voluntary  16 - 20 | challenging | mostly  PYTHON® | needs patience | possible |
| SIOS®MODULBUS | expensive | depending on task | profes-sional assem-bling is part of the job | engraver´s mechanical accuracy not sufficient, just model | missing | vocational school,  university | ready built models  up to own creations with elec-tronic  components | Special Platforms | depen-ding on Task | by choice of model or task |

\*SPS (speicherprogrammierbare Steuerung) = PLC (Programmable Logic Controller)