Evaluation

Here, the evaluation of our project according to the evaluation methods thought up in the design plan is given. Unfortunately, it was not possible to test our workshop using a Dutch target group. Thus, the other three evaluation options are used: letting the university students, who are going to execute the final workshop, analyse the workshop, letting EWB executors from previous workshops analyse our workshop, and/or evaluating our final workshop ourselves by using a checklist.

We set up two questionnaires to be distributed to evaluate the design. One of the two was distributed to the university students and one to the EWB executors. We obtained no response of the university students, and four responses of the EWB executors. Below, for each question in the questionnaire, the summarised answers of the EWB executors are given. Unfortunately, due to the university students not responding we cannot use their answers as a way to evaluate our workshop.

After the answers to the questionnaire of the EWB executors, our own analysis of the workshop is given. This analysis is made using a checklist of the design choices we postulated in our design plan..

Last, the evaluation methods and norms that can be checked using the received feedback and our own checklist analysis are repeated. We evaluate the result for each of the methods and analyse whether or not our workshop meets the norms we set.

Summarised answers to the questionnaire of the EWB executors

1. **Is this workshop too easy/too challenging for students?**
   (4/4) Over all, the workshop theory can be quite challenging.The practical assignments do have a low threshold and are well designed and at a good level

2. **Is the workshop interesting for the students?**
   (2/4) The workshop looks very interesting, the icebreakers are a very nice addition to the workshop to keep things interesting.
   (1/4) I am missing the game element in later sections of the workshop.
   (1/4) I am missing the connection of the circuits made on breadboards to real life electronic circuits.

3. **Is the time schedule realistic?**
   (3/4) Good time schedule, nice that you incorporate breaks and time to clean up.
   (1/4) The ability of the teachers to be able to manage this time properly, given their inexperience, might be too optimistic in some of the tasks and especially when the groups of students are asking and will need help.

4. **Does the workshop attain the goal (of interesting students for technology) well enough?**
   (4/4) Yes the workshop will attain the goal. Having an end result that they have hand made and given life to is crucial. Hands-on components are a plus.

5. **On a scale of 1 to 10 (10 being much, 1 being not at all): can students link the knowledge and practical skills retrieved from the workshop to something in their daily life? (I.e. is the workshop relevant for them)**

1	2	3	4	5	6	7	8	9	10
				x	x		x x		

<--->

(low relevance) **(high relevance)**

6. **Is the workshop doable for the teachers providing the workshop?**
   (2/4) Yes, definitely.
   (1/4) Yes, especially with the very handy sections of “how to guide group work” and “how to help a group with a circuit that doesn’t work”.

(1/4) If simplified a bit more and some time given on some parts, I would say it can be done.

7. **Are there comments about the student manual?**
   (3/4) Very well organized, does need to simplify, especially when approaching theory.
   (1/4) It's good that there is not too much text and there are a lot of nice visuals and images

8. **Are there comments about the teacher's manual?**
   (1/4) The lessons and learning activities are written down in a structured way that will be very helpful while giving the lessons.
   (1/4) I appreciated the session on tips and tricks and preparation for teaching! I think that can really help when you are not familiar with "public speaking" and student engagement.
   (2/4) No comments, good work.

9. **What do you think of the separation into the modules?**
   (3/4) Seems like the way to go and well organized.
   (1/4) Essential for the workshop.

Checklist of design choices

The design plan specifies design choices for the educational material developed for the Schools of the Future project of EWB. In this part of the evaluation document we will evaluate if the design choices are implemented in the final version of the workshop.

Challenges (curriculum issues)

Motivation for beta

The goal of the project was to develop material that would motivate the students for electronics and science in general. To motivate the students we developed material that connects to their daily life in some way, or speak to their imagination. We chose to structure the workshops around (electric) cars as the students are familiar with cars and toy cars. In the workshop the students will learn about electronics and build an electric car themselves. Seeing the physical result of the workshop will help motivate the students about electronics, as they will have seen how to apply their knowledge in practice.

We think building an electric car is an interesting project to work on. The students will learn how to make a simple (basic) car. They will also have the possibility to add things themselves to the base of the car, like lighting, different steering systems, sounds and sensors. Also the people of EWB seemed to like this idea. They have a clearer view of the daily life and interest of the Mozambican students. They thought that building an electric toy car would achieve the goal of motivating the students for electronics and science. Therefore we think our workshop will motivate the Mozambican students.

Irrelevance

Another curricular challenge we wanted to tackle with our workshop is irrelevance. Irrelevance is closely related to motivation explained above. The Mozambican students are mostly used to just memorize knowledge. They do not apply most knowledge they learn, especially not in a practical setting. Therefore we think that applying knowledge about electronics, that is partly present in the Mozambican curriculum, in a practical way should make the students understand the relevance of this subject. They will see how their knowledge can be transferred to practice, and learn how the toy car they build is connected to ‘real’ cars.

Learning objectives

Besides motivating students we also wanted to help them to develop skills. Specifically we wanted to focus on some of the 21st century skills, namely, collaboration, communication and technological literacy.

The students can develop their collaboration skills, as for the majority of the workshop they will work in groups of two or four. They have to discuss most of the exercises in the workshop in their groups, and build the circuits together. There was also a financial incentive to structure the workshop in this way, as less materials have to be bought when the students work together.

In the last module of the workshop, the science fair, the students will present the car they build and what they learned to other students. This module also teaches the students how to effectively do this and how to design good posters. We think these are valuable skills for the students.

As stated in our design plan we wanted to include the technological literacy skill in some capacity in our workshop. Access to computers and the internet is rare in Mozambique, therefore, many of the aspects of technological literacy are not applicable. But we hope, and think, that our workshop will show the students the application and possibilities of electronic application in their daily life.

Connection to existing education

Our client, EWB, wanted our workshop to be about electronics. They did not require that the Mozambican curriculum should be taking into account when determining the content and learning goals of the worksop.

Our workshop is centered around electronics. The students learn how to build simple circuits, electromotors and building an electric car as well as some of the theory behind these principles. Thus we satisfy the requirements of EWB on this part.

We also encompassed some of the Mozambican curriculum in our workshop. In the 10th grade students have to learn about Electrical current and electromagnetism. Specifically about electric charge, current and Ohm's law. These are principles that our workshop encompasses. In our workshop the students will see these principles in practice. Some of the recommended experience that the Mozambican curriculum specified are present in our workshop. Namely, building series and parallel circuits to verify the behavior of current and voltage, and working with an electromagnet.

Foreknowledge

Most students will probably not have many foreknowledge about electronics. Some may have learned about it in school, but their knowledge will probably not extend further than memorised definitions. So we could not assume the students had any knowledge about electrical circuits.

Our workshop teaches the basics of electrical circuits without delving too much into theory. Therefore any student should be able to follow most of the workshop. Our workshop is split up in multiple modules. This allows each module to focus one a few concepts. We also tried to make the modules as independently as possible. While the modules are not completely independent we included summaries of previous workshops that briefly explain the knowledge that you need in later modules. The module were the students can combine all the knowledge of the workshop to build a car can still be done if a couple of previous workshops are missed. But if all modules are done, the students will be able to build a more elaborate car with more features.

Taking diversity into account

We designed the workshop to accommodate different type of students. The main focus of the workshop is building electrical circuits, without going too deep into theory. In most modules extra theory is included. Therefore students that are more into theory have the option to learn the theory behind the practicals. Students that are more into practical work can still do the workshop and enjoy it without this extra material.

Didactic approaches

Authentic approach

With the authentic approach, a learner acquires meaningful insight for themselves starting from intrinsic motivation and building on prior knowledge. Learning takes place in a relevant, practical and real-life context. Communication and interaction with peers has a central role within the authentic approach.

We designed the workshop with the goal of building something fun and practical. making a car speaks to the imagination of the students. The students work together to realise this goal. With the help of the icebreakers and practical assignments, we try to activate the prior knowledge of the students, and learn them how this connects to electricity. Therefore we think our workshop adheres to the authentic approach.

Concept-context approach

In the concept-context approach the focus lies on connecting knowledge to a real life context. This has overlap with the authentic approach. We encourage the students to think how the circuits they build can be applied in their daily life and specifically to ‘real’ cars. We hope the students get more interested and motivated by making this connection. We think our workshop does achieve this.

Teacher’s guide

The workshops will be taught by students from the Eduardo Mondlane University. These students are inexperienced with teaching, so the teachers guide provides a clear structure for each module of the workshop. This includes the preparation for a module, the knowledge the teacher needs, the learning goals and time schedule for the module and a step by step guide for teaching the module.

We also included a ‘tips and tricks’ section in the teaching guide that should help the student teachers. This includes tips about teaching in general, interacting with students, how to motivate students, how to guide groups and what to do if students get stuck building an electrical circuit.

Student’s guide

All students will be given a student’s guide which they will use during the modules. The student’s guide is structured so the students only have to read the module in which they participate at the moment. This way, the students that missed a module will not have the

feeling they’ve missed something. However, by adding summaries in all modules, the students can easily check what the last module was about. These sections are also useful for the students that were present to recall what they did in the last module. If the modules are not given two days in a row but rather in a longer time span, these summaries will be very useful to all students. The students can write in the document to answer questions, draw circuits and brainstorm (mind map). Thus, If they take the document home, they can read it through another time while more easily remember what they did and learned in the module(s).

Cost evaluation

Engineers without border prefered the workshops to cost less than 15 euro per student. Here we include an overview of all necessary materials. Shipping costs are kept at a minimum by buying items that combine multiple elements. All materials can be shipped to Mozambique. We also included a list of other materials necessary for the workshops, not included in the price that can probably be bought in Mozambique. Note that shipping batteries to Mozambique is expensive therefore we recommend to buy them in Mozambique if possible. The total excluding shipping amounts to 12 euro per student, including shipping and other material we estimate the cost to be around 15 euro per student.

Electronics kit

- 1 Breadboard link1 €2.17 per piece, link2 €0.98 per stuk
- 1 Light sensor link1 €2.17 per 2 pieces
- 5 220Ω resistor link1 €2.17 per 10 pieces
- 5 Push button link1 €2.17 per 6 pieces
- 5 LEDs link1 €2.17 per 15 pieces (random color)
- 2 electric motors (DC motor) link3 €11.81 for 6 pieces
- 2 fans link3 €11.81 for 6 pieces
- 2 wheels link3 €11.81 for 4 pieces
- Variety of axes, gears and rubber bands link3 €11.81 for 2 sets
- 3 Slide switches link4 €0.26 per pieces, link3 €11.81 for 6 pieces
- 1 Battery pack with 2AA batteries link5 €2.20 per 10 pieces, link3 €11.81 for 6 pieces link11 14,57 for 50 batteries
- 20 jumper wires link6 €0.53 per 40 pieces
- 1 Potentiometer link7 €1.10 per piece
- 1 Active buzzer link8 €0.99 per 10 pieces
- 1 Proximity sensor link9 €0.73 per piece
- 1 10kΩ NTC sensor link10 €0.26 per pieces NTC explanation 10kohm NTC has 439 ohm/deg sensitivity

Total: €12.00 (11.81/2 plus the rest)

Other materials, cost not calculated

- Rope
- scissors
- magnet
- A3+A4 (colored) paper
- A2 poster paper or cloth banner with paint
- coloring and drawing pencils
- cardboard
- Glue gun with glue sticks
- Rubbing alcohol
- Plastic straws
- Copper wire: 1 x 2m, 2 x 3cm and 2 x 6cm

- Piece of sandpaper
- Nipper

Evaluation methods, norms and results

Using the answers to the questionnaire and the answers to our own checklist evaluation, we can check the results of the evaluation methods, and see if the norms are met.

The following assumptions should be evaluated:

1. A workshop based on the reality of the students will contribute to a higher interest in technology, since they can directly see how they can use there new retrieved knowledge and developed skills in their daily life.
2. All design choices are translated into the design.

The following design choices should be evaluated:

1. We want to use a modular workshop, to discriminate in level and opportunity.
2. The workshop must motivate the participating students for technology and science, while transferring knowledge comes second.

Methods, Tools and norms to evaluate assumptions and design choices

Each of the assumptions and design choices that are to be evaluated are sorted in one of the four categories: Relevance, Consistency, Usability and Effectiveness. In these sections the methods, tools and norms to evaluate the assumptions and design choices are given. When multiple methods are used to evaluate a single assumption, a table will be presented.

Relevance

The first assumption that should be evaluated: “A workshop based on the reality of the students will contribute to a higher interest in technology, since they can directly see how they can use there new retrieved knowledge and developed skills in their daily life.” tells us about the relevance and effectiveness of this workshop. For this assumption to evaluate to true, the first part of the assumption (the pre-condition) should evaluate to true. Therefore in this section we will evaluate if the workshop is relevant. Later we will evaluate if the students interest in science and technology is increased, which is also captured in the second design choice (effectiveness). If the workshop is both relevant and effective, the first assumption evaluates to true.

Desired: The students see a link between the workshop and their reality, and thus the relevance of the workshop.

Methods & tools:

Method	**Tool**
Questionnaire EWB executors	Questionnaire EWB executors Question: On a scale from 1 to 10, how relevant do you think the workshop is for high Mozambican high school students?

Norm:

Method	**Norm**
Questionnaire EWB executors	On average the EWB executors rate the relevance of the workshop for Mozambican high school students at least a 6 or higher.

Result:

Method	**Result**
Questionnaire EWB executors	The average rating for the relevance of the workshop of the EWB executors was an 6.75, which is higher than the 6.0 we used as our norm. We therefore think the workshop is relevant enough

Consistency

Here, the second assumption is evaluated: “All design choices are translated into then design.” If not all design choices are translated into the actual design we should know that our design might be lacking at these points. Using this evaluation we can see where our design would be lacking and then we can redesign to make all design choices apparent in the design.

Desired: The finalised workshop is based on all the design choices posed in the design plan.

Method & tool:

Method	**Tool**
Checklist	The screening method will be applied, where the designers make a checklist summarising all design choices. This checklist is then used to check if all the choices that have been made in the design plan are translated into the workshop.

Norm:

Method	**Norm**
Checklist	All the choices that have been made in the design plan are translated into the workshop.

Result:

Method	**Result**
Checklist	Using the checklist we argued that all design choices have been implemented in our workshop. Some, like the technological literacy skills are only represented in small parts of the module, but nevertheless we incorporated all our ideas of the design choices in the workshop.

Usability

The first design choice that should be evaluated: “We want to use a modular workshop, to discriminate in level and opportunity.” tells us about the usability of this workshop. The modularity should enable us to discriminate in level and opportunity, while not making it too difficult for the teacher to give the workshop.

Desired: The modularity of the workshop does not affect the ability of students to follow the workshop in whole, or the teacher to supervise the workshop. Even if students miss a module they should be able to continue the workshop and contribute to the final module. The average level of the modules should fit the level of the class, such that all students should be able to successfully finish every module. For teachers it should be clear how the workshop is structured by reading the teacher’s manual, without any external help.

Method & tool:

Method	**Tool**
Questionnaire EWB executors	Questionnaire EWB executors Question: Is the workshop doable for the teachers providing the workshop?

Norm:

Method	**Norm**
Questionnaire EWB executors	All EWB executors should rate the workshop as doable, if any concerns are seen, the workshop should be revised.

Result:

Method	**Result**
Questionnaire EWB executors	3 out of 4 executors rate the workshop as very doable. Especially the addition of “tips and tricks for teaching” makes the workshop easy to use. 1 out of 4 executors rate the workshop doable if the level of the theory in some of the modules is scaled down. As the norm set for the usability is not passed, we have edited our workshop. The most difficult modules have been revised and some of the theory has been moved to the “extra material” section, to make the main part of the modules and the workshop easier and more clear. Now the norm has been met..

Effectiveness

The second design choice that should be evaluated, “The workshop must motivate the participating students for technology and science, while transferring knowledge comes second”, tells us about the effectiveness of the workshop. The workshop must motivate the participating students for technology and science, while transferring knowledge comes second.

Desired: Students are more interested in technology and science after the workshop.

Method & tool:

Method	**Tool**
Questionnaire EWB executors	Question: Do you think this workshop will increase the interest of Mozambican high school students in science and technology? (on a scale from not at all to very much)

Norm:

Method	**Norm**
Questionnaire EWB executors	Every EWB executor thinks the workshop will increase the interest in science in technology of Mozambican high school students somewhat.

Result:

Method	**Result**
Questionnaire EWB executors	All executors say that the workshop will attain the goal of increasing the interest of Mozambican high school students in science and technology very much. Having an end result that the Mozambican students have hand made is crucial for this. Our norm has been surpassed.

Recommendations re-design

As we have evaluated our design, we can offer some recommendations for a possible re-design in the future. The following recommendations can be distilled from the feedback we obtained:

Make the theoretical part of the workshop easier.

The main feedback of the EWB executors was about the level of the workshop. They think it is a bit too theoretical for the Mozambican students. We already tried to change the structure of the workshop to make the workshops less theoretical, by moving the theoretical knowledge to “Extra Material”, that is mainly present for enthusiastic students.

In a complete redesign the workshops could be completely designed with a ‘practical first’ mindset. This means that first is decided what circuits the students will work on, and then add the theory about those circuits later in on optional section. In our design we also took concepts in mind that we want the students to learn. Therefore part of the practical assignments are now based around those concepts, instead of designed with only a focus on practice.

Introduction to the breadboard

In the first module, the students get familiar with the breadboard. They have to connect multiple components to this breadboard including a battery. In this module, the goal is to introduce the students to the breadboard and to these multiple components (how these work). However, feedback of EWB was to have a more general start of this workshop because the students have never used electronic components. There should be more time scheduled for introducing the students to how an electronic circuit works in general. In this part, there can be more elaboration on what electricity is or where you can find it, how electricity can only exist in an *connected* circuit and how a breadboard is used to manage this connection.

Clearer link between circuits and daily life

Another comment we got was that the students might not be able to relate the content of the workshop to their daily life. In our design a car takes centre stage, but maybe not all students will be able to relate to this. In a redesign more circuits that the Mozambican students use in daily life could be incorporated. More analyses of the daily life of students is therefore necessary. Sources on this are very scarce, therefore we suggest a closer cooperation between the designers and EWB to get a good view of the life in Mozambique.

The student’s guide should be more independent

In our design there are places in the student guide where it refers to something the students saw during the workshop. For example there are reference in the student’s guide to something the teacher explained during the module. An EWB executor would like it better if

the student's guide would not include those references, so that students can learn from it outside of the workshop.

Variety during the modules

The modules are constructed of practical and theoretical work and in most modules, this is preceded by an icebreaker. However, the duration of the modules is around two hours, so it would be nice to have another icebreaker or fun game in the middle of the module. This way, the work done by the students won't feel repetitive. Also, the attention span of students at the age between 14-18 is limiting so an extra icebreaker in between may be beneficial to the workshop.