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sustainablySMART

Sustainable Smart Mobile Devices Lifecycles through Advanced Re-design, Reliability, and Re-use and Remanufacturing Technologies

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Contributing Partners

Preliminary findings by the lead author have been discussed and developed with the members of the sustainablySMART consortium in sessions during the 5th General Assembly in Pyla, Cyprus, in September 2017 as well as during the 6th General Assembly in Oulu, Finland, in March 2018. In addition, the project partners were consulted for repair criteria validation via a survey format.

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Reparability Scoring System

Executive Summary

IFixit GmbH has produced a web-based application which can evaluate a mobile end user device (smartphone or tablet) on its reparability. The goal of the scoring software is to capture the characteristics of a specific product by means of a consistent and reproducible scoring procedure, and to then store the product and assessment data to be able to compare and rank devices in the same product category.

The application consists of two assessment modules: a module for heuristic assessment, consisting of a questionnaire / criteria list based system for capturing qualitative, mainly context-related aspects of a product; and an ease of disassembly (EoD) assessment module that quantifies product-related aspects of reparability. This document will give an overview of the key frontend and backend components of this application.

In the frontend, the user of the software will first create a product record, will then capture all activities involved in the disassembly process, and will lastly answer a set of questions regarding the product. The information thus entered via the user fronted will lastly be processed to evaluate, score and report the reparability of the specific product in the result section of the user interface.

For administration purposes, the software application has been equipped with a backend layer, where admins can manage all assessment-related elements within a content management system (CMS), and can also store, retrieve and export product data sets via the system's product assessment database (PAD). Currently, the software backend can only be accessed and maintained by iFixit GmbH administrational staff.

1 Introduction

The web-based application consists of two modules (figure 1): on the one hand, a heuristic assessment module consisting of a criteria list based questionnaire system with a focus on capturing context-related product aspects (like the availability of a repair manual or of critical spare parts); on the other hand, an ease of disassembly (EoD) logging system that captures product-related aspects of reparability (like the types of tools used and the concrete activities performed during disassembly).

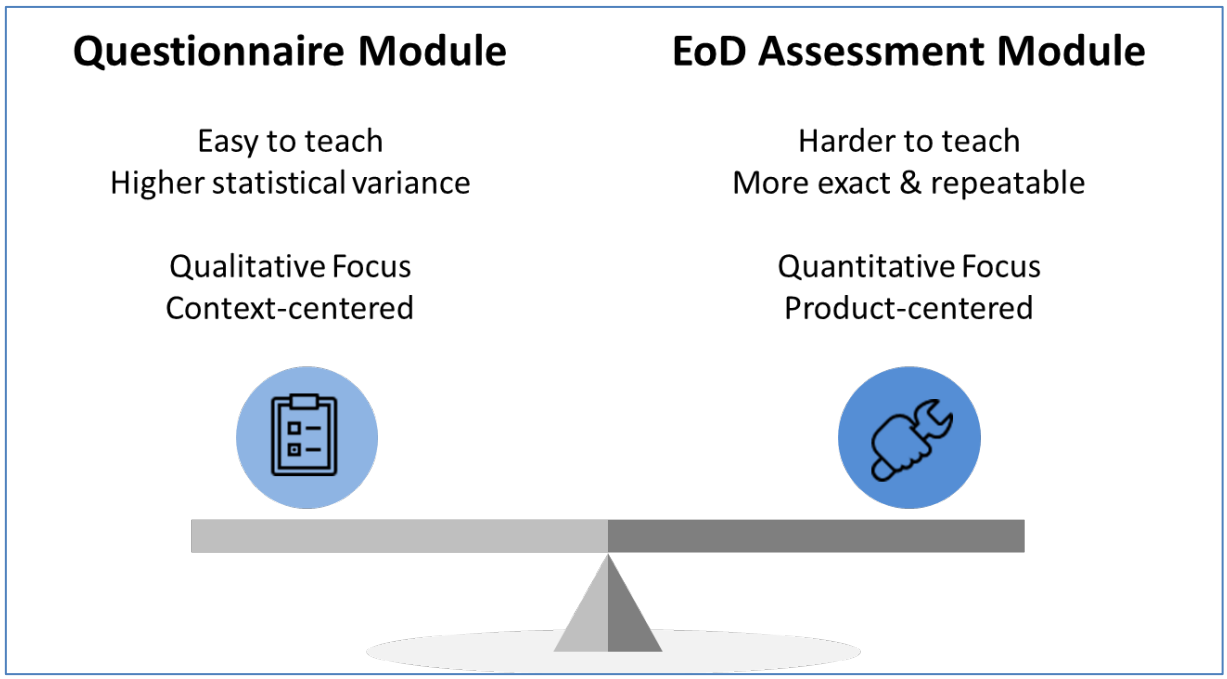


Figure 1: Finding a balance. Strengths and weaknesses of the two assessment modules

For both modules, the software is able to handle generic repair criteria (that apply to all products) as well as criteria that are specific to an individual product category. In principle, it is therefore possible to take into account sets of tools, disassembly activities or contextual questions that are needed for the assessment of a specific product group beyond mobile electronics (like household appliances or other product categories).

The assessment data are initially stored as local cookies; if the assessment situation should require it, it is therefore possible to perform a reparability assessment without automatically uploading the results to the online database of the web application. Instead, product datasets can be stored on (and retrieved from) the local computer used for the assessment. This local data storage alternative was implemented to allow for a degree of privacy in the context of assessment scenarios like prototype assessment.

The software application is structured as shown in figure 2. The frontend user interface provides product assessors access to the application. Currently, user access is password-protected and requires permission from iFixit GmbH. The backend, accessible only to administrators, allows setting the assessment content and scoring rules for the reparability scoring system. Frontend and backend are described in more detail in the following chapters.

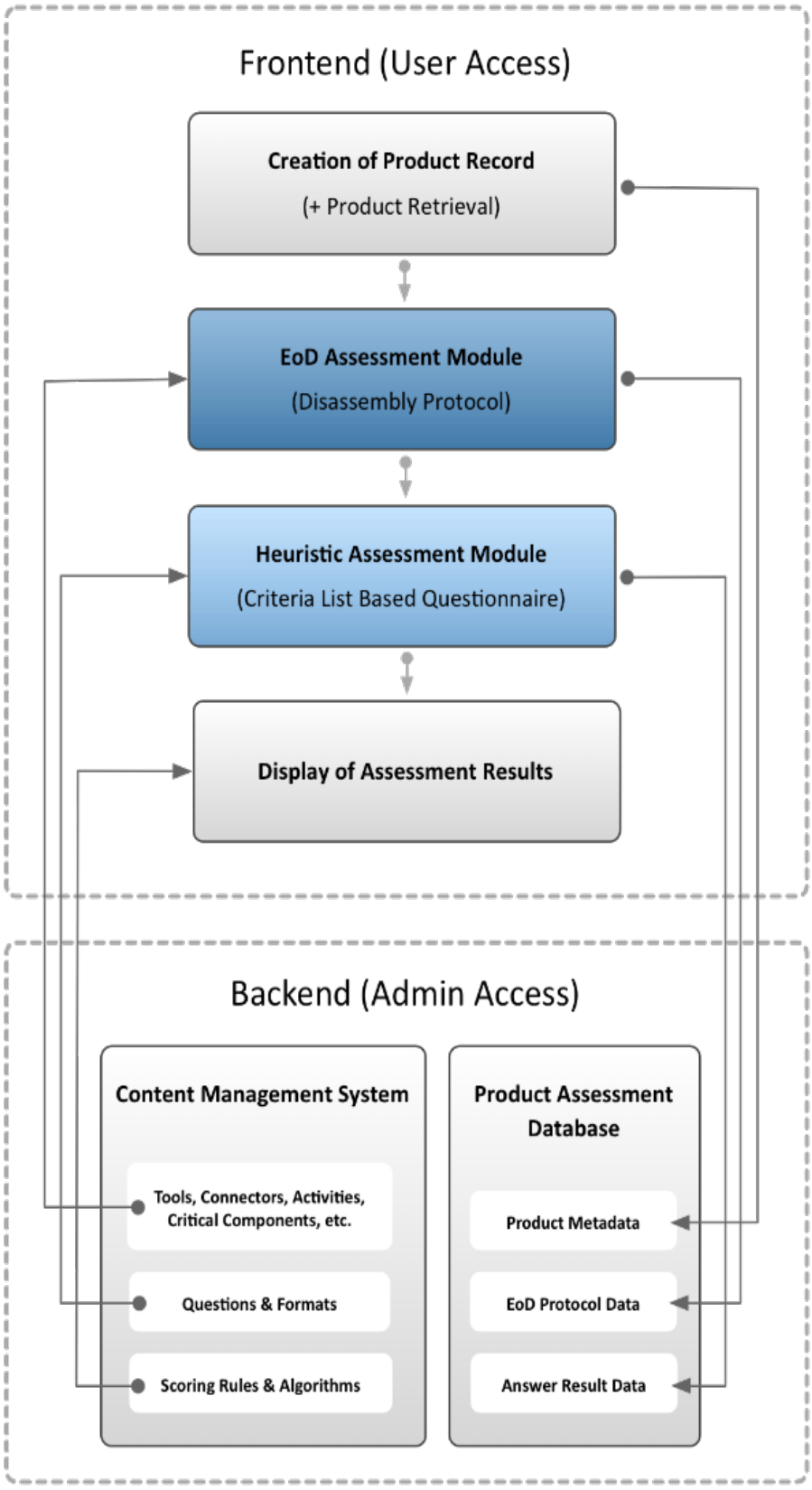


Figure 2: Functional diagram of the scoring application

2 Frontend

The frontend user interface is the place where the assessor will enter the data for evaluation to then receive the assessment result. The frontend consists of six tabs that appear gradually as the user progresses through the assessment.

The first three consist of the *Category*, *Products* and *Evaluation Details* tabs, where products are newly created or an already existing dataset can be downloaded from the online database; here, specific product and assessment data is entered before running through the actual assessment procedure.

After creating or downloading one of the existing product records, the user will complete the *EoD* assessment module, where all activities concerning the disassembly procedure are entered. Following this process, the user will be working through the content displayed in the *Questionnaire* tab, where he/she will have to answer questions concerning the context of the product.

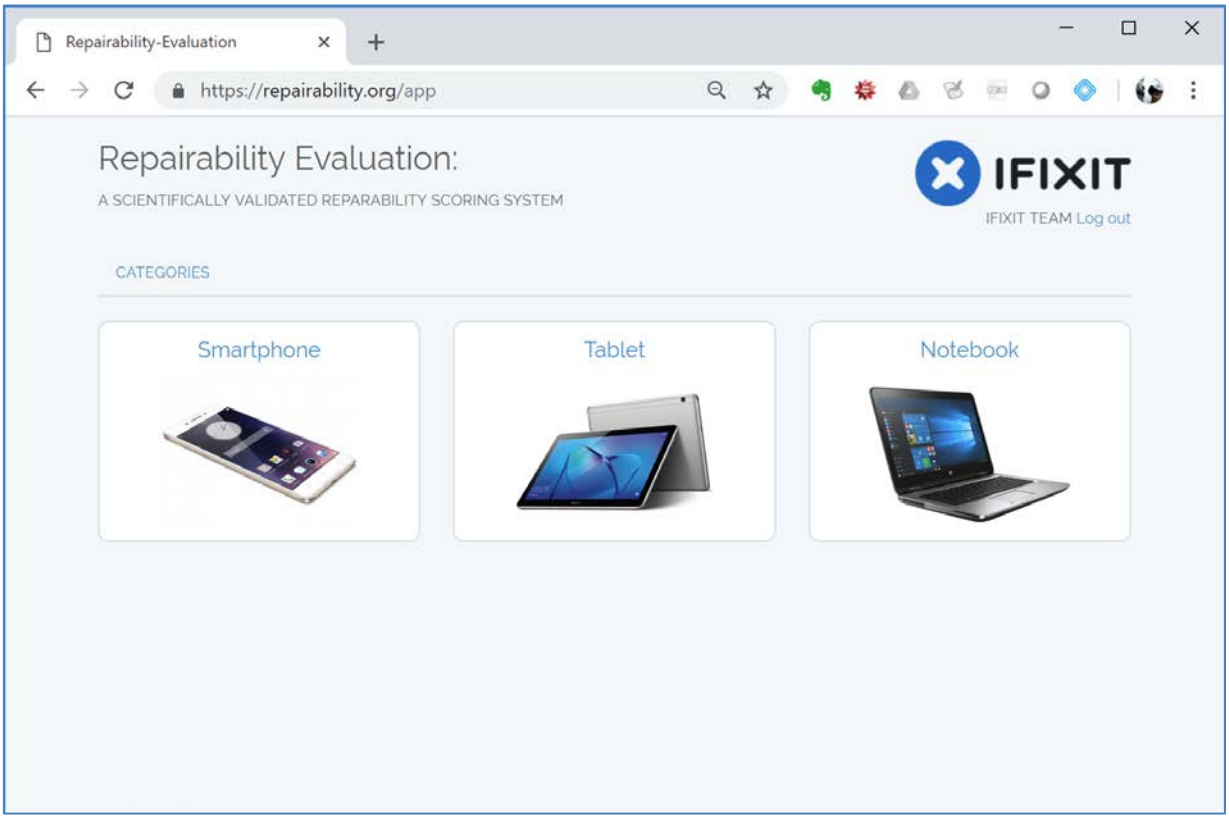
The final tab will show the results of the assessment, taking into account different parameters from the EoD activity log and the questionnaire module.

2.1 Creation of product record

2.1.1 Categories

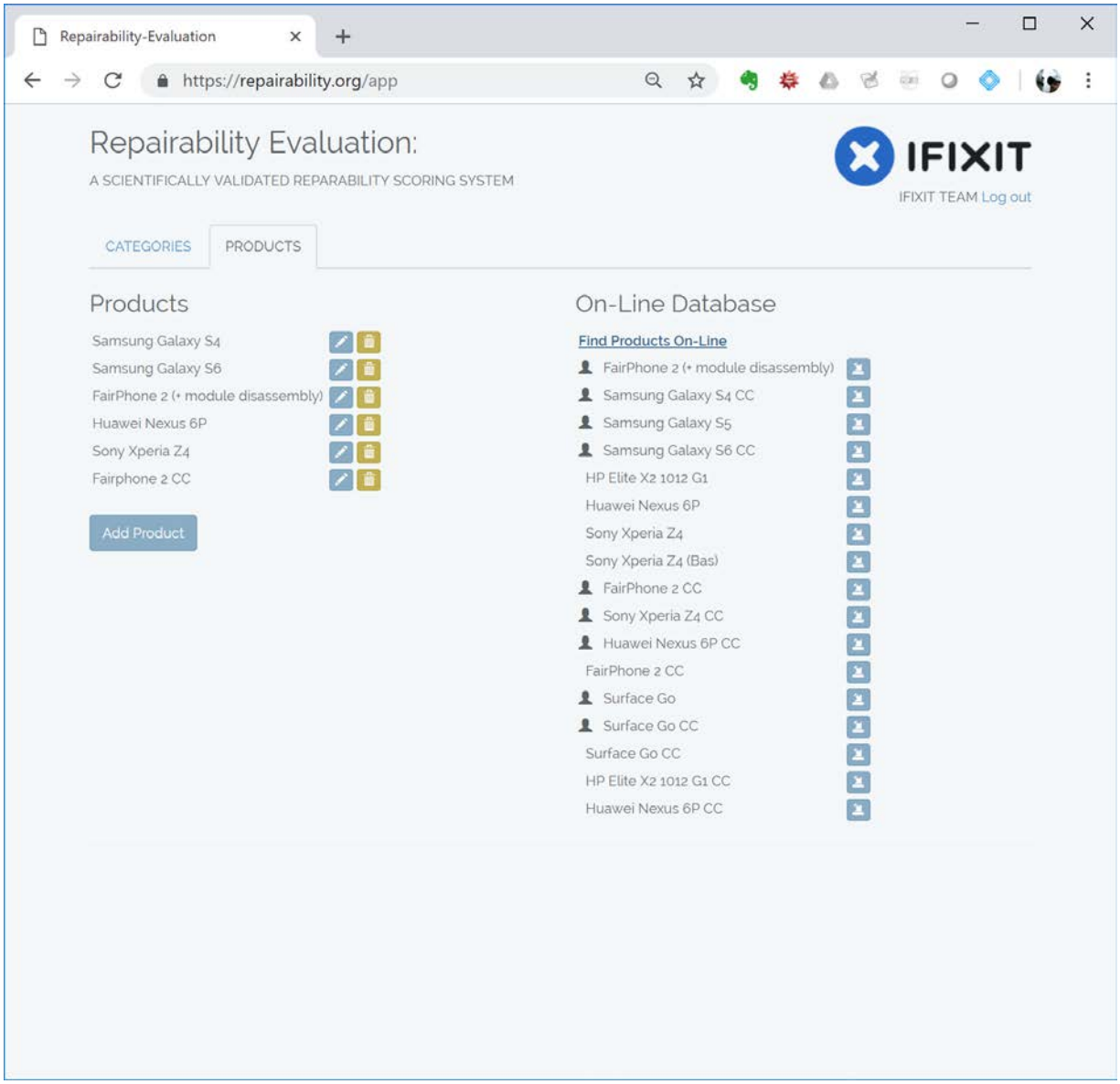
To get started, the user can make a choice in which category he/she will evaluate a product. At this moment three categories are defined in the system, the *Smartphone*, *Tablet* and *Notebook* categories.

The initial category choice defines the category-specific criteria, and directly affects what assessment elements (tools, activities, questions, scoring rules etc.) are being pulled from the backend. Selection of a category loads the next tab, “Products.”



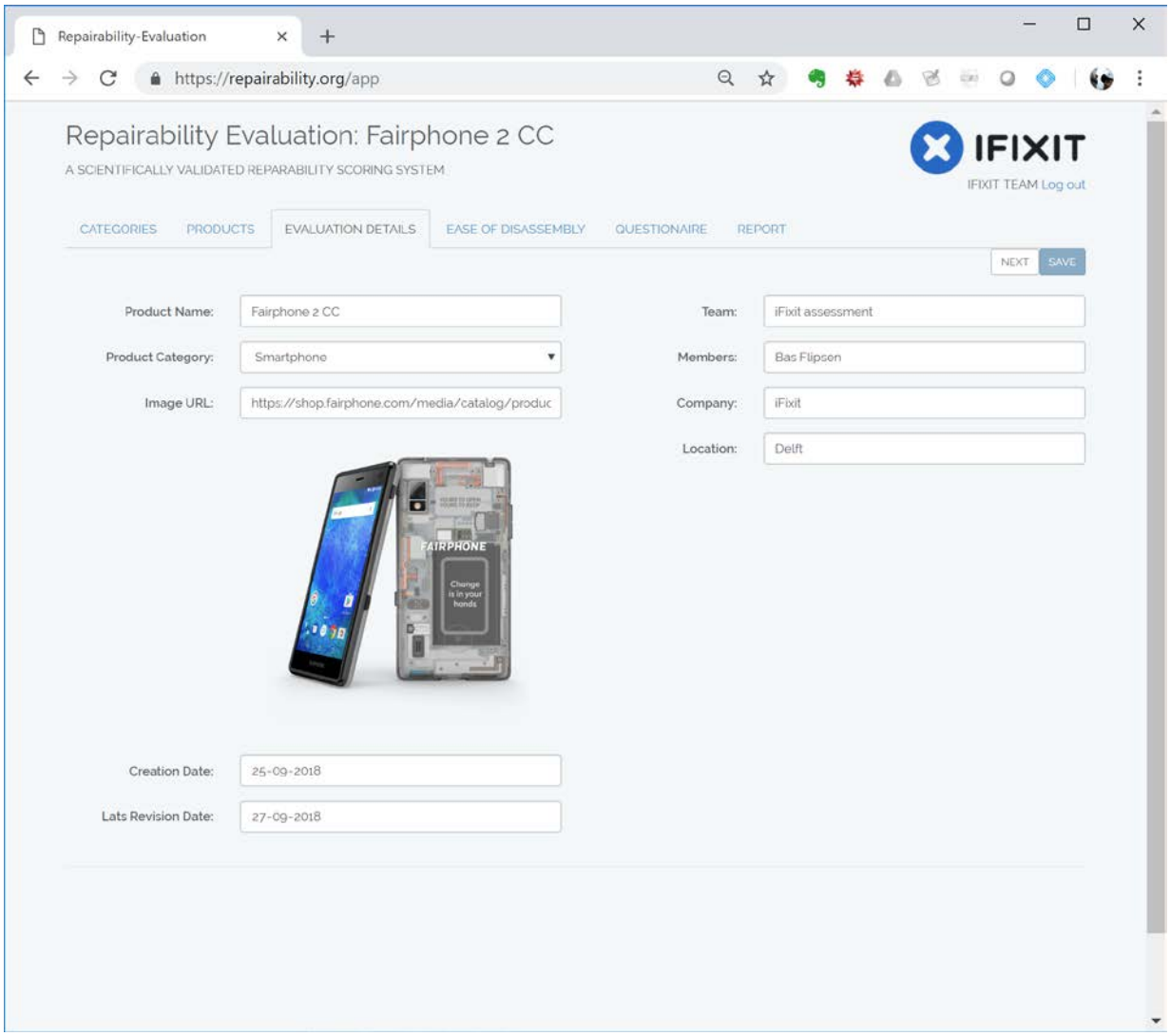
2.1.2 Products

Under the *Products* tab, the user can add a new product, open a product dataset that's available on her/his own computer (left side column) or load one of the products available online by clicking "Find products online" (right side column).
The product assessment profiles that are available online consist of publicly shared products (accompanied by the human silhouette icon), or products that are available only to the team that is working on them.
The user can load a product assessment profile by clicking the download button, and can then open it by clicking the pen symbol.



2.1.3 Evaluation details

After opening a product assessment profile, additional tabs will be shown, and the next tab in line will introduce the user to the *Evaluation details*. The user can now enter the necessary data for the specific product to be assessed and the details for the assessment team.
A product image can be uploaded and the product category can be adapted here, if necessary. The creation date and the last revision date are updated automatically.



2.2 Ease of Disassembly assessment module

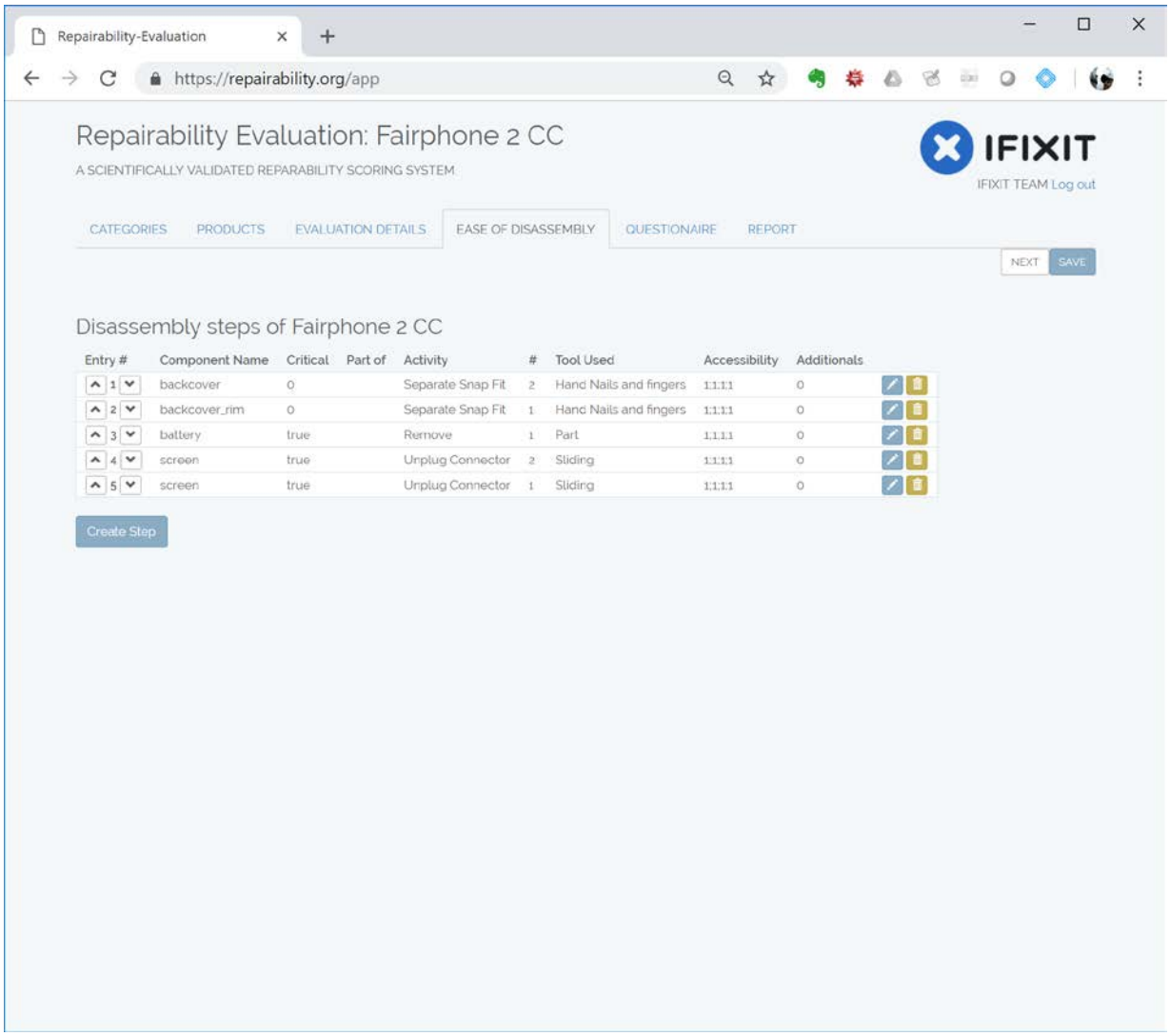
2.2.1 Ease of Disassembly

The *Ease of Disassembly* module tab displays a table that consists of a log of all activities that are needed to disassemble the product to its critical components or/and all other components. This logging concept is based on the Ease of Disassembly tables developed by Ehud Kroll[1], which in turn is an approach that is based on the MOST Work Measurement System[2].

Each individual line in this table refers to one distinct activity needed to disassemble a specified component. When multiple activities are needed for disassembling one component, additional lines have to be logged for it.

The user can add a new activity by clicking the “Create step” button.

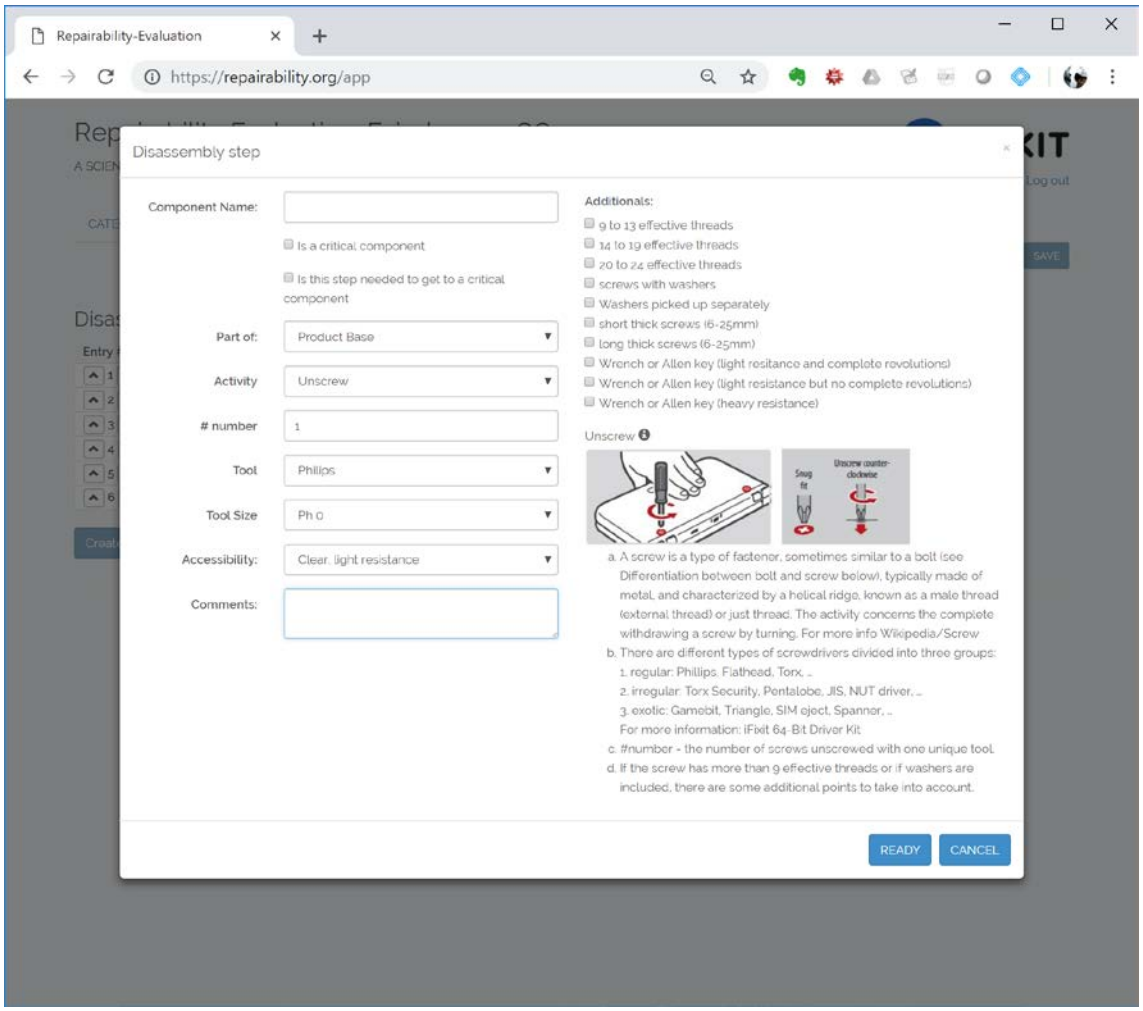
[1] Ehud Kroll (1995), “Ease-of-Disassembly Evaluation in Product Recycling”, Texas A&M University.
[2] K.B. Zandin (1980), “MOST work measurement Systems”, New York: Marcel Dekker.



2.2.2 Create step

For every individual step of the activity log, the user has to enter its specific details, like the components' name that the step refers to, if the step deals with a critical component (CC) or if it is needed to get to one of the critical components in the device.
To log that a component is part of a subassembly, the user can also specify whether it is part of another component. The activity itself, the number of times this activity is done in a row, tool and tool size needed to perform it, and the accessibility aspects of the activity are logged here. The user can tick box "Additionals" that are specific to this type of activity and needed to capture it concisely, for example when longer screws are used or washers had to be picked up during this activity step.

A user guidance system has been implemented: Should users need more information on a specific activity, they can click the small information icon that will explanatory details (in visual and textual form) regarding the activity and about filling in the form correctly.



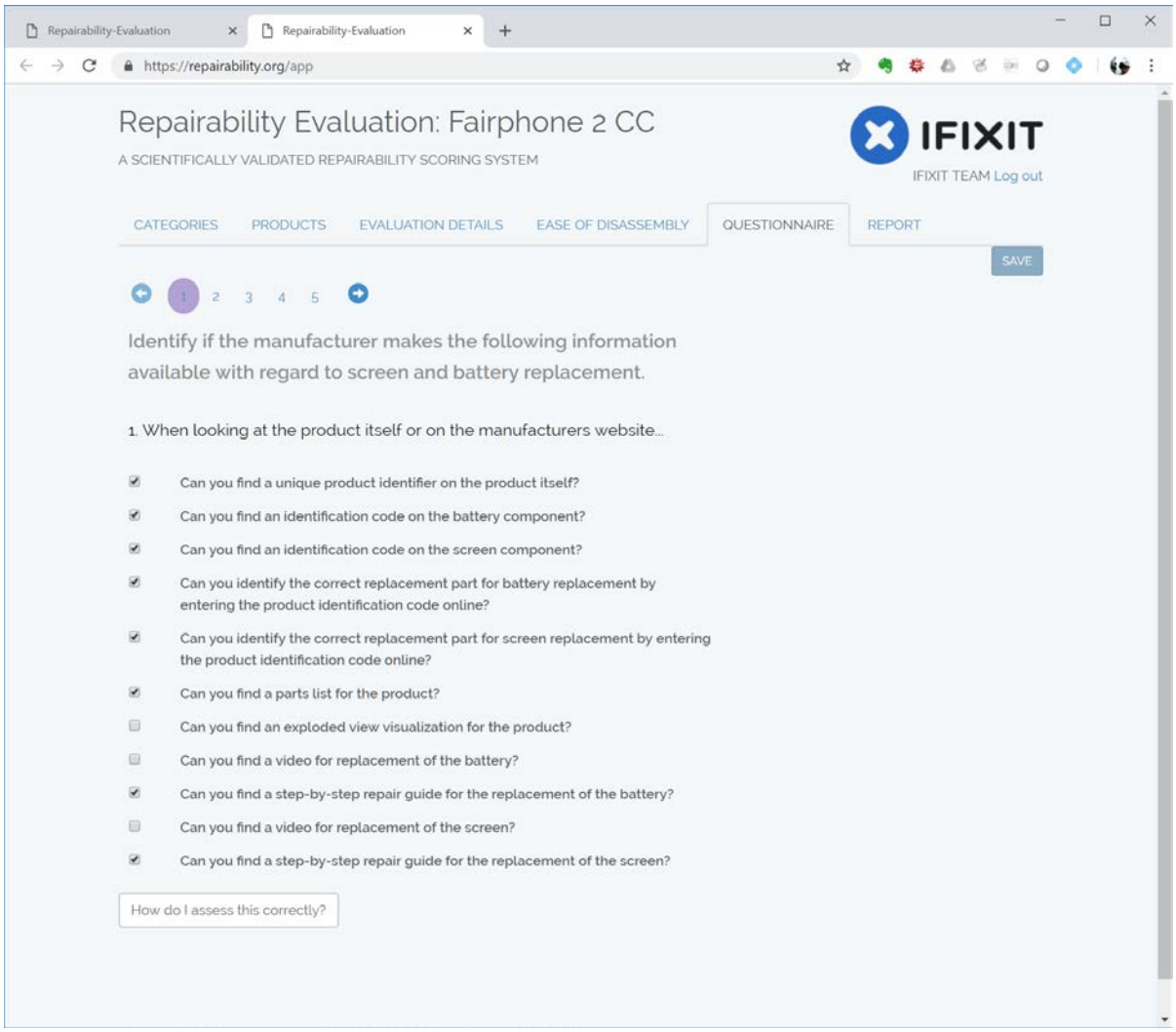
Heuristic assessment module

2.2.3 Questionnaire

After finishing the EoD activity log, the user will have to run through a series of questionnaires, where questions are asked that capture aspects of repair criteria with a qualitative focus. At the moment, two types of question formats have been implemented:

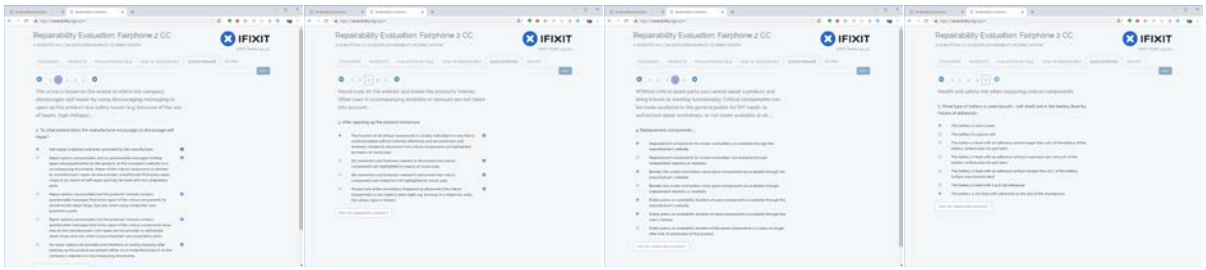
(i) multiple selection using checkboxes (more than on option can be checked)
(ii) multiple choice using radio buttons (only one option can be checked)

Extra information regarding each answer is available by means of an info button or/and contextual roll-overs.



For the implemented assessment of smartphones and tablets, the user has to answer 5 lists of questions regarding:

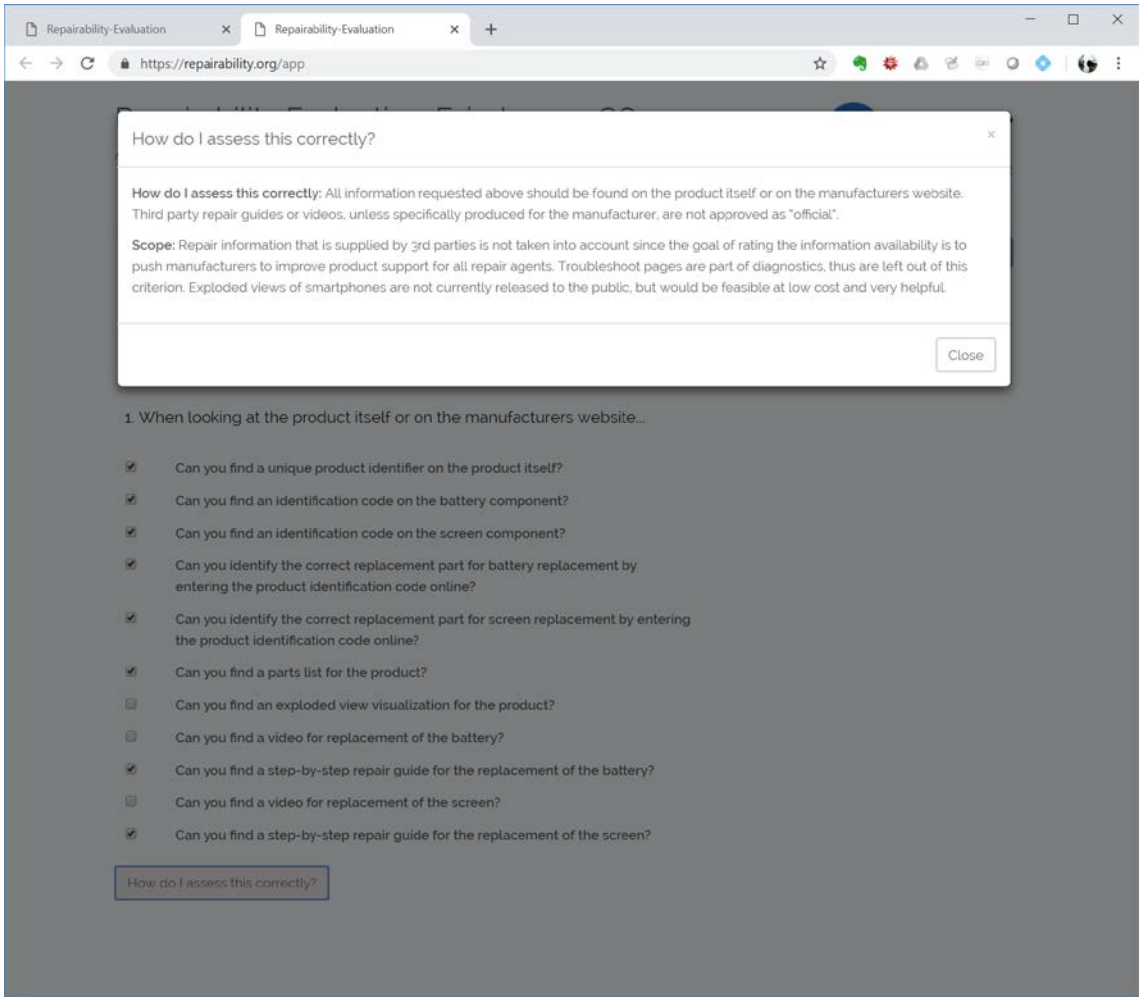
a) the availability of repair information
b) the use of deterrent messaging to discourage the user to perform a repair
c) the use of visual cues on and in the product directing the repairer towards a successful disassembly
d) availability of replacement components at OEM or third-party suppliers
e) health and safety issues relating to the product



2.2.4 Protocol user guidance: »How do I assess this correctly?«

To aid all users in answering the questions precisely and in correct scope, a central help button is available at the bottom of every questionnaire page; when pressed, a popup box is made available.

In this popup, the user will find information on how to assess the the criterium correctly; depending on the user guidance required, it can include text, hyperlinks and images.



2.3 Display of assessment results

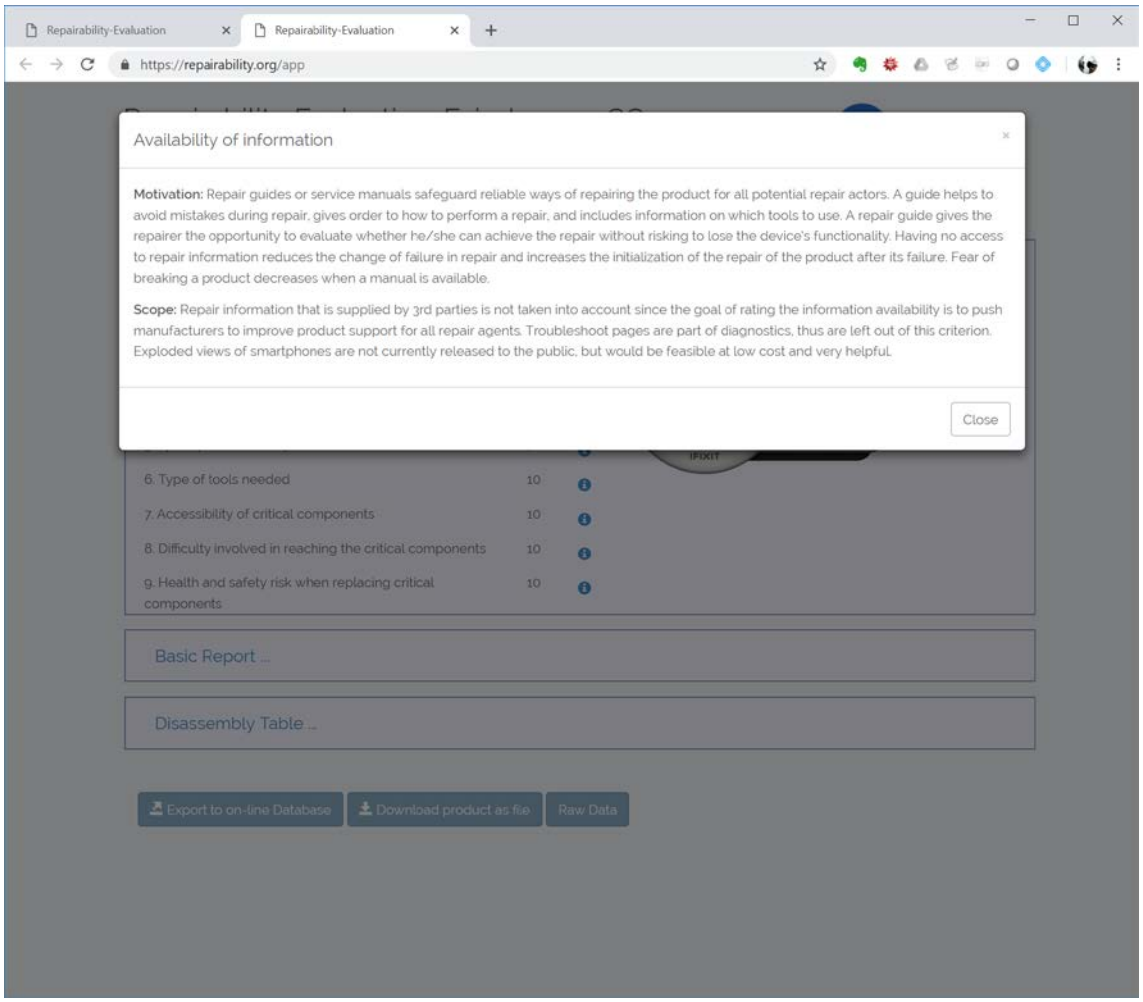
2.3.1 Report

After finishing with the two modules, the results of the reparability assessment will be shown on the page “Result”. The result page consists of three parts:

1. Individual score for each of the different criteria, with an aggregate total reparability score
2. Basic report which provides the user context and product-specific information regarding the product and the disassembly
3. Disassembly table showing all steps for the disassembly.

The user can save the assessment in a local file (cookie), download the file as a RAW data file for later use, or upload the assessment to the online database via the “export” button and so share the assessment within the team or make it publicly available.

The motivation for and explanation of every repair criterion can be viewed by pressing the information button behind the criteria titles in the list on this page. Clicking this button will display to the user the definition and the scope of the specific criterion.


Repairability-Evaluation
Repairability-Evaluation
https://repairability.org/app
Availability of information
Motivation: Repair guides or service manuals safeguard reliable ways of repairing the product for all potential repair actors. A guide helps to avoid mistakes during repair, gives order to how to perform a repair, and includes information on which tools to use. A repair guide gives the repairer the opportunity to evaluate whether he/she can achieve the repair without risking to lose the device's functionality. Having no access to repair information reduces the change of failure in repair and increases the initialization of the repair of the product after its failure. Fear of breaking a product decreases when a manual is available.
Scope: Repair information that is supplied by 3rd parties is not taken into account since the goal of rating the information availability is to push manufacturers to improve product support for all repair agents. Troubleshoot pages are part of diagnostics, thus are left out of this criterion. Exploded views of smartphones are not currently released to the public, but would be feasible at low cost and very helpful.
Close
6. Type of tools needed 10
7. Accessibility of critical components 10
8. Difficulty involved in reaching the critical components 10
9. Health and safety risk when replacing critical components 10
Basic Report ...
Disassembly Table ...
Export to on-line Database
Download product as file
Raw Data

3 Backend

For administration and flexibility purposes, the software application has been extended with a backend, where the administrator manages content in the content management system (CMS), and the products in the product assessment database (PAD). The backend is only accessible by iFixit admin staff.

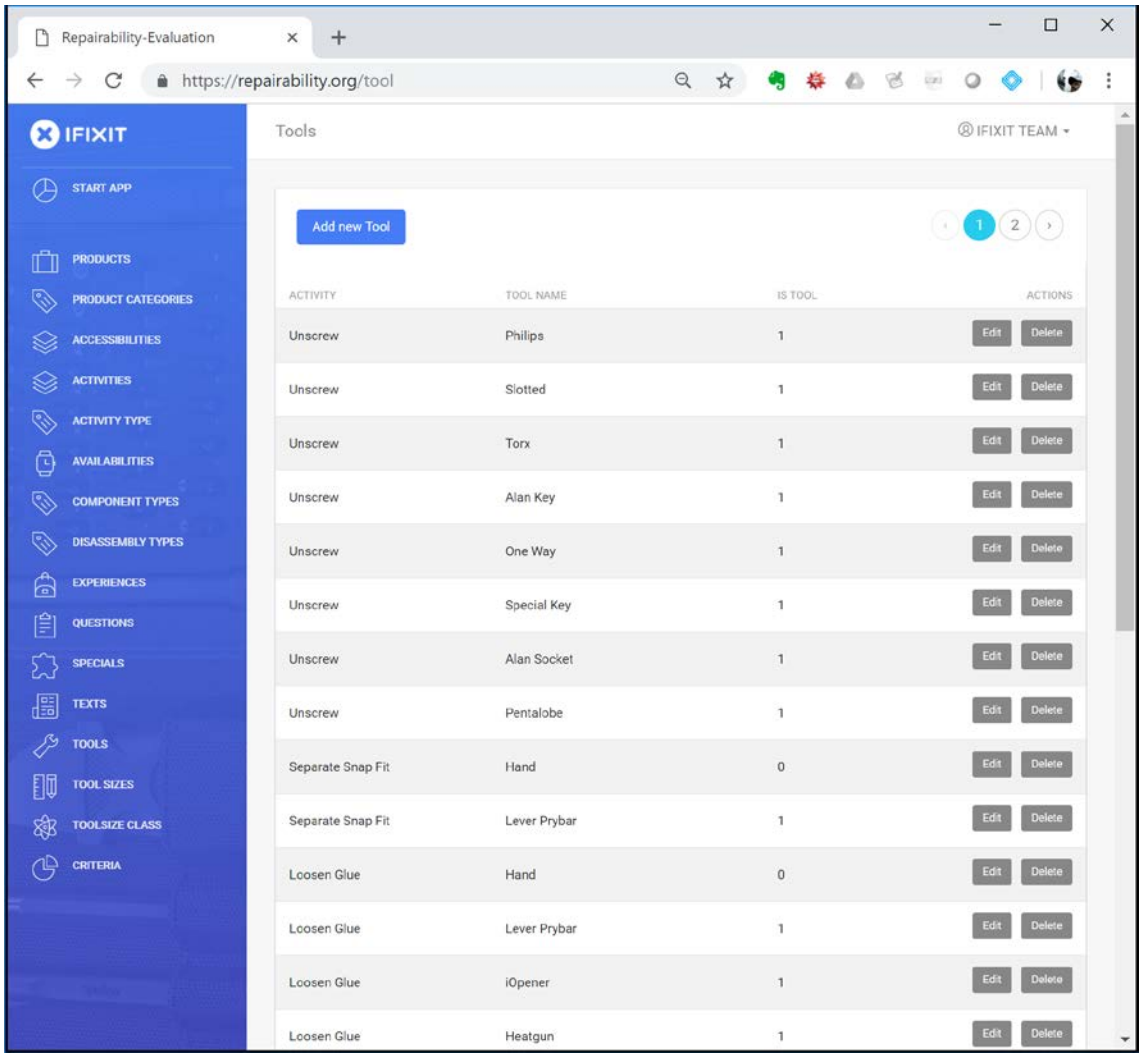
3.1 Content Management System

The content management system is used to add, edit and delete the elements needed for the frontend to present its content to the user and to calculate the score correctly. It consists of the administration modules for tools, activities and the scoring of all activities (via accessibility, force, positioning, base time and special additionals), and it also allows for the monitoring of the questions needed for the heuristic module and the criteria where all variables hat have been put in during assessments come together in a sub-scores per criteria and the final score (which is a function of the weighted sub-scores). Using the product metadata module, the administrator can add, edit or delete product assessments. The CMS is only accessible by the administrators at iFixit.

3.2 Tools, activities, accessibilities and specials

3.2.1 Tools

Within this backend section, the administrator can manage the database of tools.



3.2.2 Tool Sizes

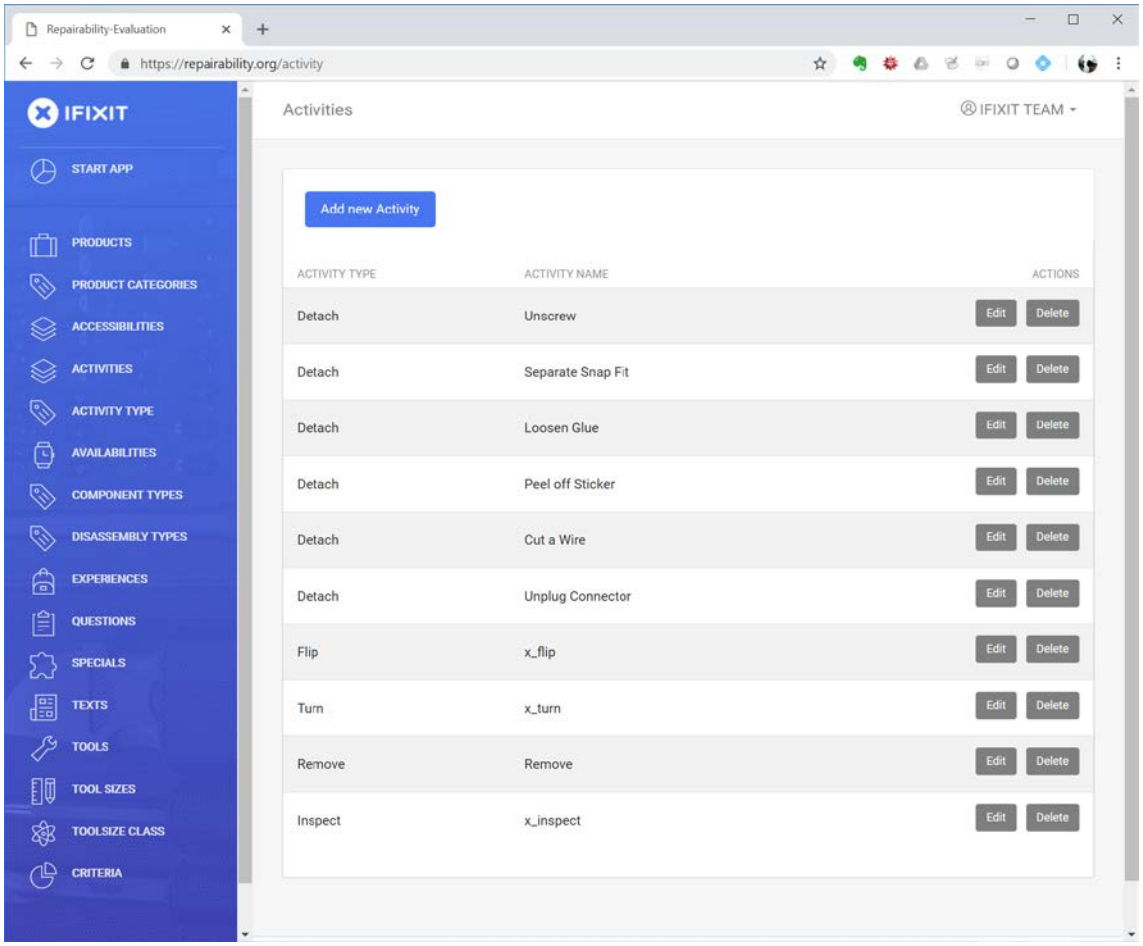
In the “Tool sizes” tab, the administrator can manage the different tools sizes and the corresponding tool type. All tools are classified from Class A, being a commonly available tool, to Class D, being a company-specific tool not available for a general repair agent.

3.2.3 Activities

The administrator can here manage the activities made available for selection to the user. The activities the user can input are e.g. “Unscrewing”, “Separate snap fit” or “Remove”.

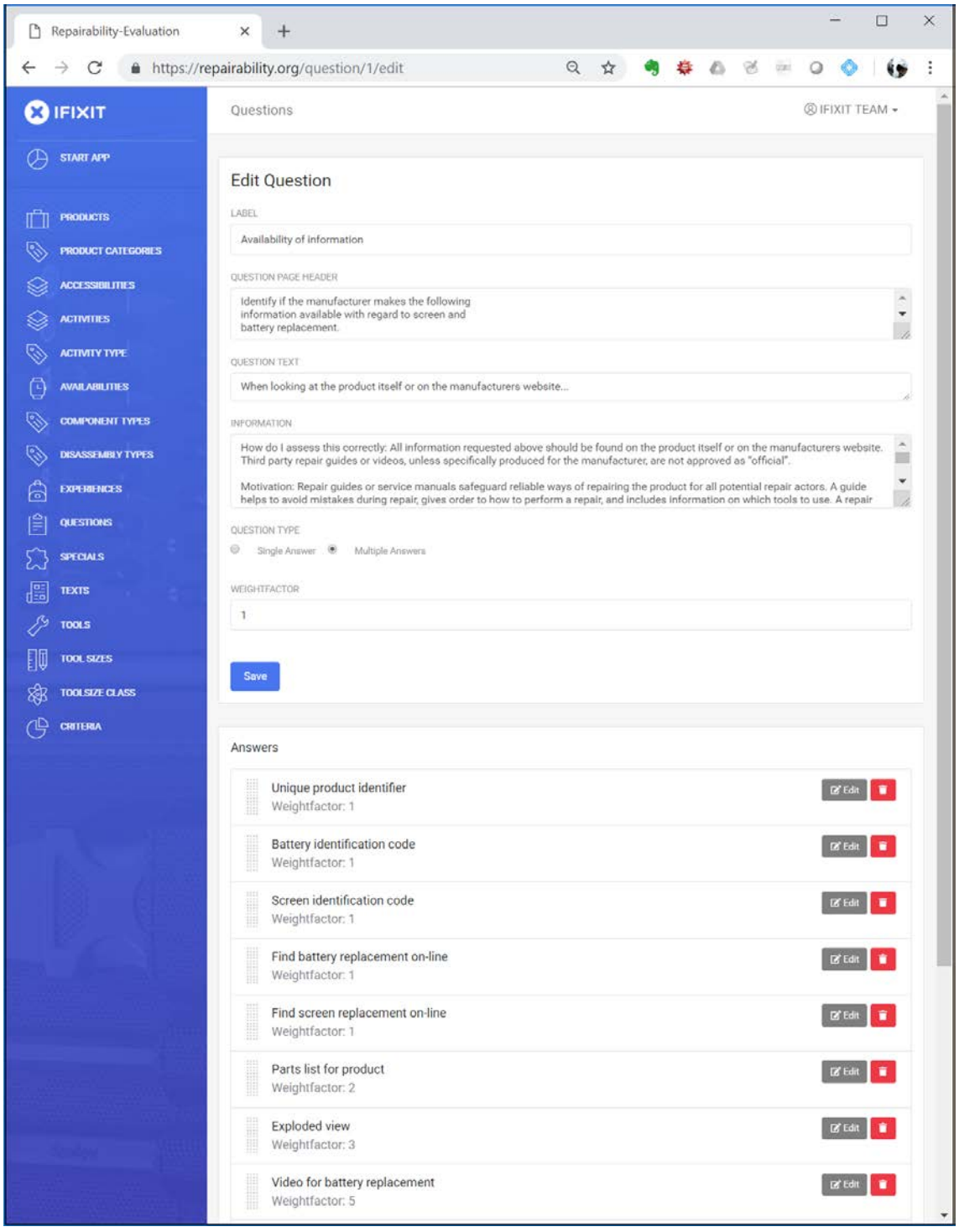
3.2.4 Accessibilities

To come to a time-based score, the administrator can here edit the accessibility-related time, positioning-related time, force-related time, base-time and the extra time (named specials) needed for actions like taking out washers or the use of extra-long screws. The different time-variables are based on the disassembly evaluation chart from Ehud Kroll (1995).



3.2.5 Questions

In the Questions tab the administrator can add, delete or edit questions. These questions are needed as input as variables for the criteria defined under the tab “Criteria”.
Editing the questions will give the administrator the options to change the question page header, the question text, the information on how to answer this question, and the question type, be it multiple choice, “single answer”, or multiple selection, “multiple answers”.
Besides the general information concerning the question, the “Answers” can be edited and each can be given a weight factor which will be used as input for the scoring algorithm.



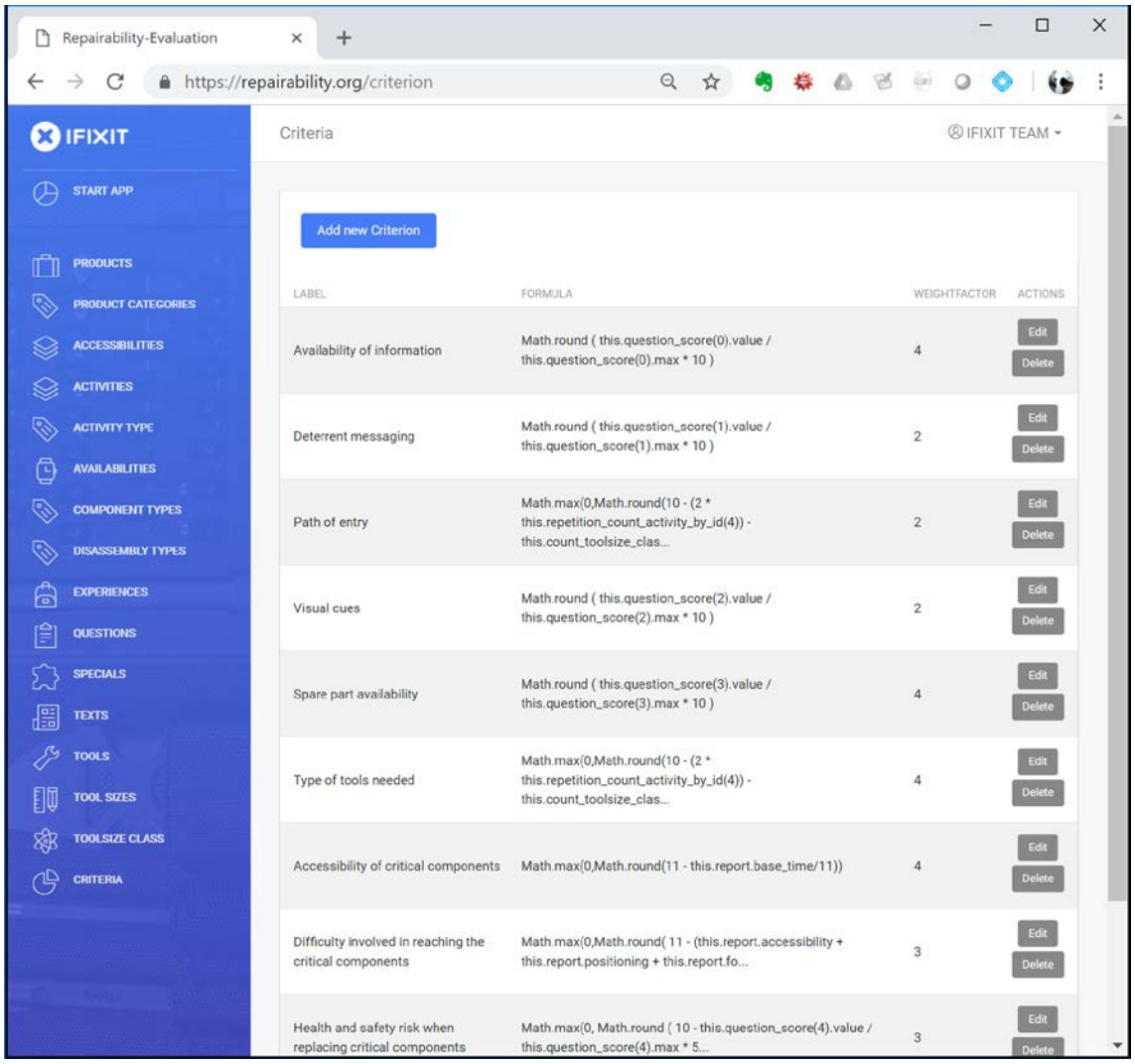
3.3 Scoring Rules & Algorithms

3.3.1 Criteria (rules)

Products are assessed on, in our case, 9 repair criteria. In the backend of the software application, the administrator can add, edit and delete criteria.

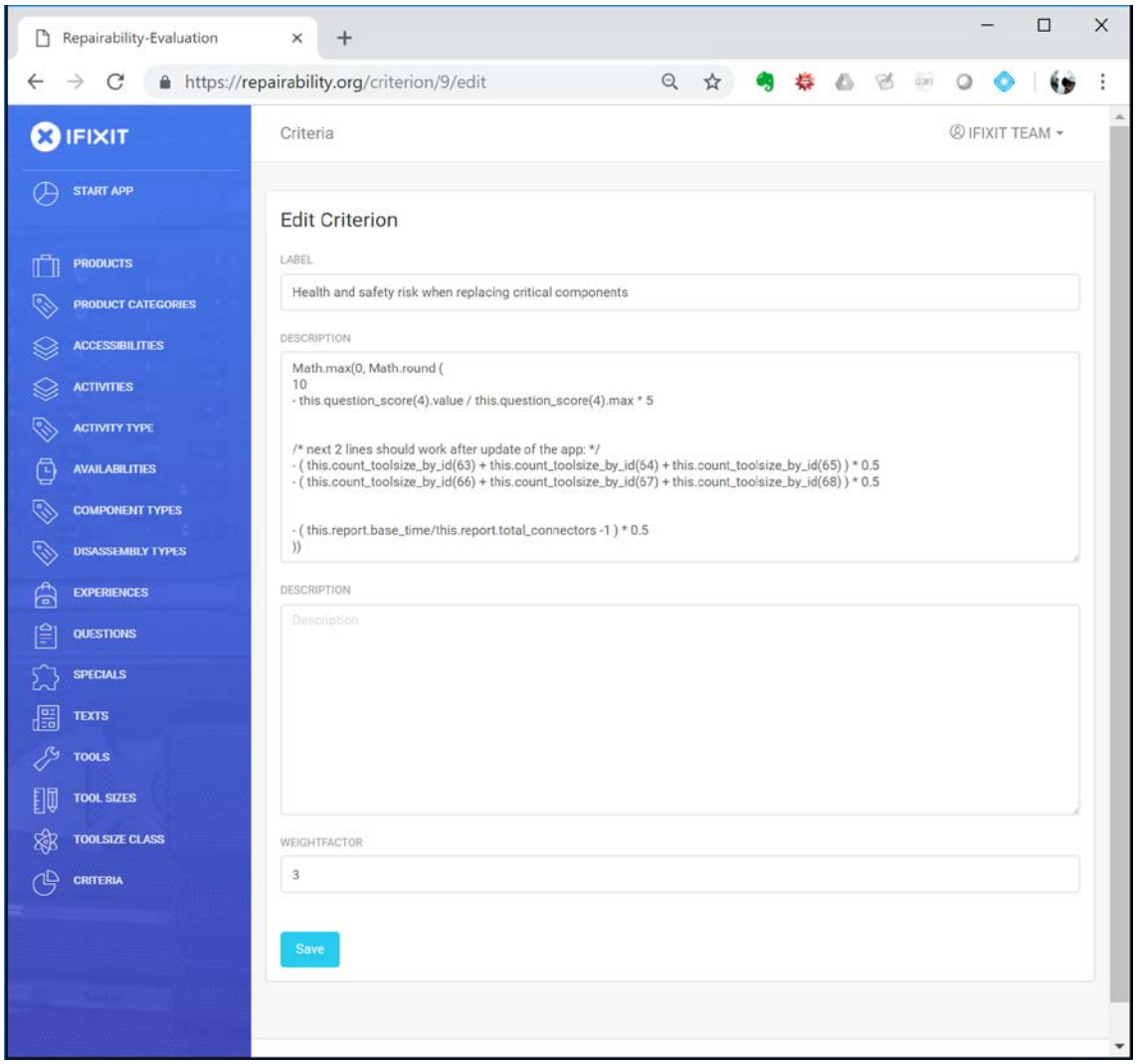
Within every criteria entry, the administrator can edit the evaluation algorithm which is defined by means of a formula, using as its inputs the EoD activity log and the answers from the questionnaire.

To come to a final score, every criterium can be individually weighted for contribution to the final score. This weight factor is based on the importance of the criteria (where 1 is means low importance and 4 is very important).



3.3.2 Formula (algorithm)

The edit button gives access to modifications of criteria as well as to formula that translates the response for a specific criterion to a rating on a scale from 0 to 10.
The formula is fed by data from the questionnaire module and the ease of disassembly module. The specific example on the right uses data from both modules.



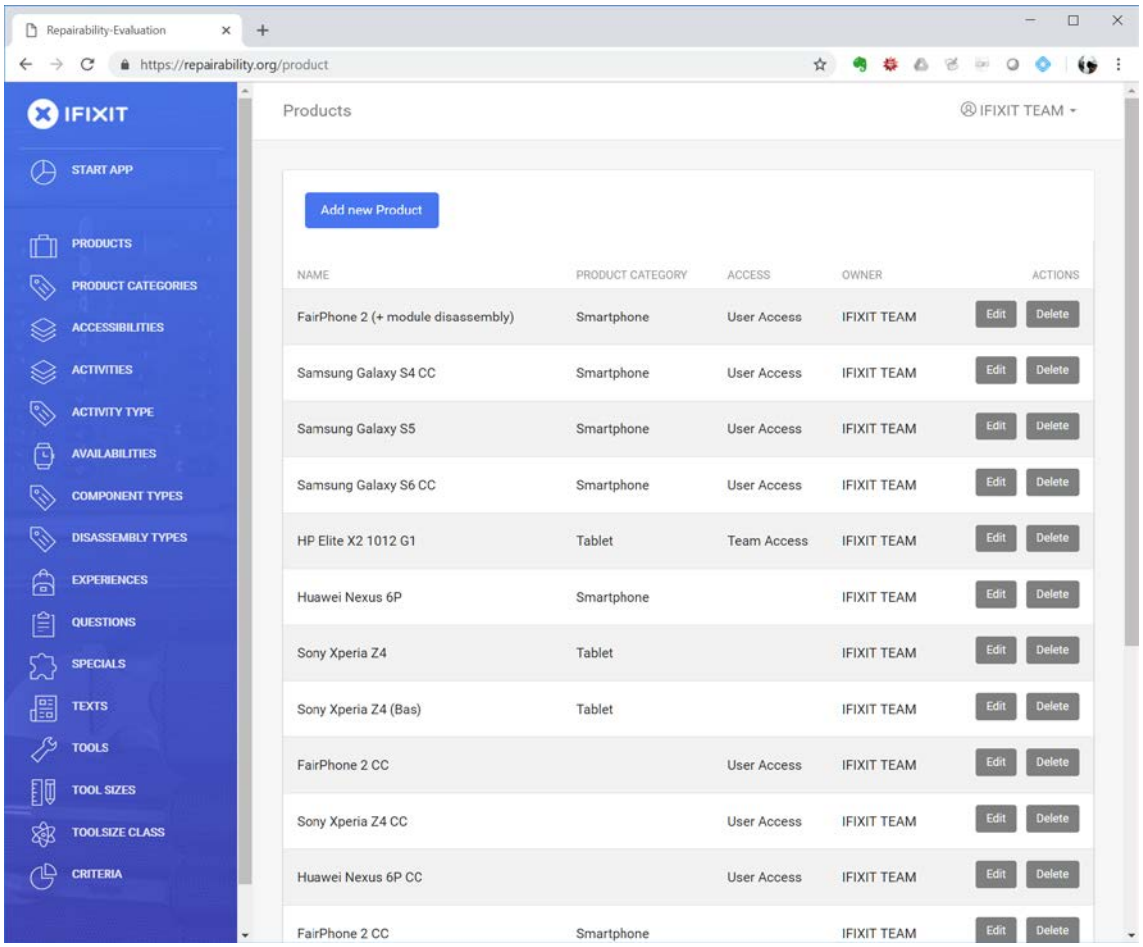
3.3.3 Product Assessment Database

In the product assessment database, all the relevant input data, like product metadata and also the results from the two questionnaire module (Answer Result Data) and the EoD Assessment module (EoD protocol data), is being stored. Below, the product metadata is explained.

3.4 Product Metadata

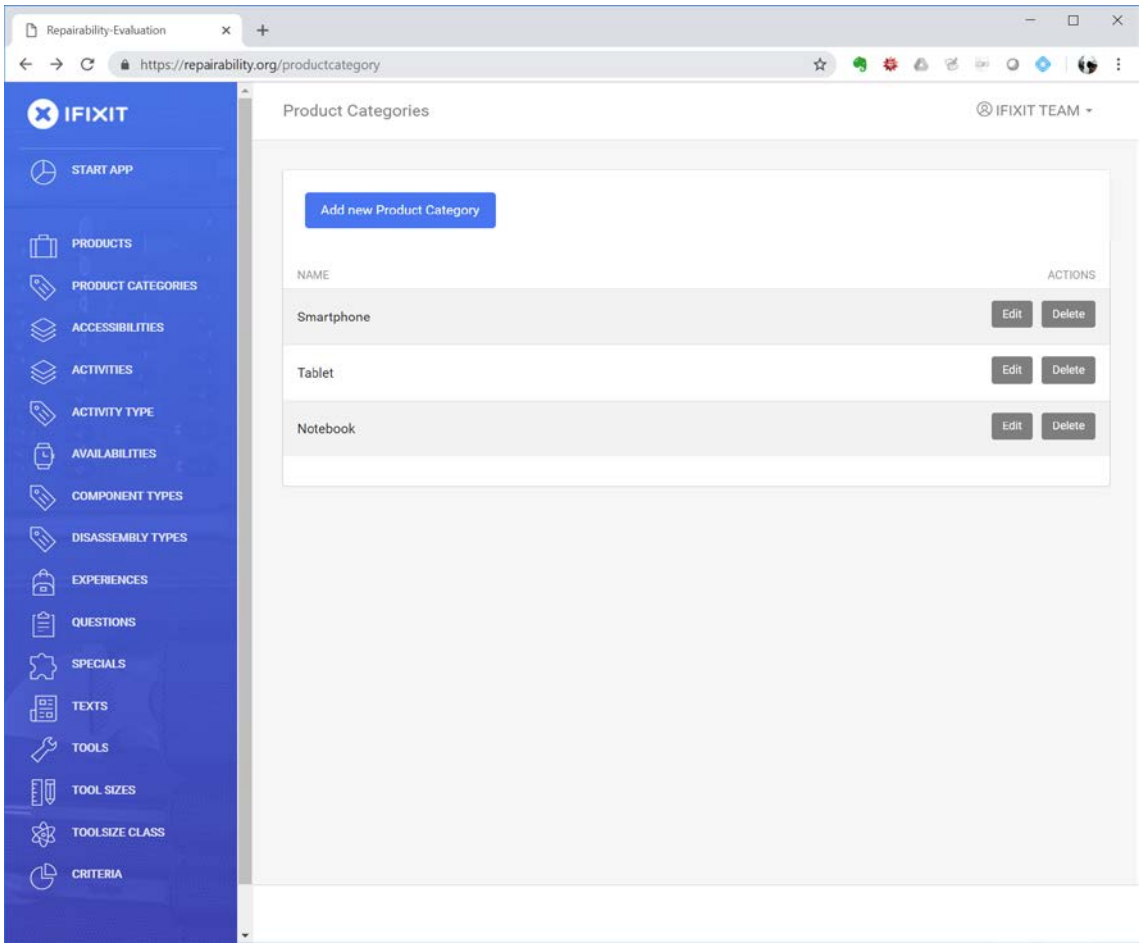
3.4.1 Products

Under the “products” tab, the administrator can edit and delete the products uploaded to the database. Here, the administrator can control the access rights to of the different products, as either user-specific, team-based or as publicly accessible.
Furthermore, in this part of the backend, product datasets can be duplicated and then used for alternative assessments.



3.4.2 Product Categories

When clicking the “product categories” tab, the administrator can add, activate, edit and delete the product categories this tool can assess. The product category defines the category-specific questions and criteria.


Repairability-Evaluation
https://repairability.org/productcategory
IFIXIT
START APP
PRODUCTS
PRODUCT CATEGORIES
ACCESSIBILITIES
ACTIVITIES
ACTIVITY TYPE
AVAILABILITIES
COMPONENT TYPES
DISASSEMBLY TYPES
EXPERIENCES
QUESTIONS
SPECIALS
TEXTS
TOOLS
TOOL SIZES
TOOLSIZE CLASS
CRITERIA
Product Categories
IFIXIT TEAM
Add new Product Category
NAME
ACTIONS
Smartphone
Edit
Delete
Tablet
Edit
Delete
Notebook
Edit
Delete