# Grant Agreement Number 612367


Including Responsible Research and innovation in cutting Edge Science and Inquiry-based Science education to improve Teacher's Ability of Bridging Learning Environments

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# 1. Executive Summary

The aim of the Web2.0 / App Guide is to support the Community of Learners in each country to include Web2.0 / App tools in the module. Following the idea to use these technologies all way along the IBSE path, the guide offers various tools for different requirements in the respective phases. The most relevant tools of the guide were presented at the Web2.0/App Workshop (Deliverable D4.2) in Kiel early March 2014.

To simplify the integration of the tools in the teaching modules, a document "Examples of using ICT in a learning unit - Additional ideas of how the tools could be integrated in the IBSE modules" was prepared. The examples illustrate the integration of ICT tools in different teaching settings, targeting all core aspects of the IRRESISTIBLE project, like RRI, IBSE, gender issues and exhibitions.

The Web2.0 / App Guide as well as the examples-document are available for download on the irresistible homepage[1]. They will be updated and expanded during the project, including new tools used in the partner modules.

[1] http://www.irresistible-project.eu/index.php/en/resources

# Table of Contents

# 2. MAIN PART

## 2.1 Web2.0 / App Guide

The aim of the Web2.0 / App Guide is to support the partners when developing the modules. Giving them a bunch of tried-and-tested tools at hand, that are already available should make it easy to include these tools, or to find similar tools that probably fit the respective module needs even better.
After screening the marked for tools that sounded relevant for the project, a first selection of more than 100 tools was tested before choosing the top 30 to be included in the guide.

The Web2.0 / App Guide is structured in three parts:

A) A brief **introduction** sheds light on smartphone usage in general, on how many smartphones are in use in the relevant age group, and on the marked shares of the different operating systems.

B) The second part of the guide lists 30 relevant, tried-and-tested **Web2.0 / App tools** that could be appropriate for use in the modules. Tools from the following eight fields of application are listed:

| | |
|---|---|
| Project Tools | Collaborative work |
| Image Work | Knowledge |
| Measuring | Tools |
| Mobile Office | Exhibition |

A detailed list of all tools is included in the appendix.

C) The third part of the document is a **quick start guide** to the open-source ePortfolio system **Mahara**. Mahara renders a promising platform for the work in the modules, offering not only a versatile collaborative working space, but also a shielded social network with tools as journals (private/internal), a blogging tool, easy to program (dragand-drop) web pages (privat/ internal/ external), collaborative work pages, a resume builder, ... Mahara can be used as stand-alone system or be integrated in a larger network, e.g. with its 'sister' application Moodle. An internal test instance of the ePortfolio system Mahara was set up to allow the partners / people working in the CoL to evaluate the system for their needs.

irresistible

# The Web2.0 / App Guide

Ideas for tools that could be used in the IBSE modules

Lorenz Kampschulte

March 2014

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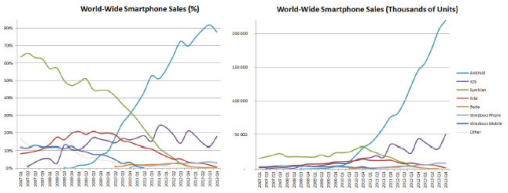
IRRESISTIBLE is a project on teacher training, combining formal and informal learning focused on Responsible Research and Innovation.
This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no 612367.

## Smartphone sales

In 2013, almost 1 billion of smartphones was sold worldwide, a growth of 42.3 percent from 2012. Android is by far the most widely used operating system with over 78 percent of smartphones sold in 2013 running Android, followed by iOS with a 16 percent market share, and Windows Phone reaching three percent.[2]

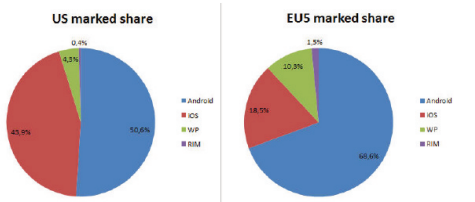



Worldwide smartphone sales in percent and in thousends of units. In the last quarter of 2013, almost 220 million Android smartphones and 50 million iOS devices were sold. Windows Phone with about 8.5 million units sold is slowly growing, but still far off the two big players.[3]

The tablet market is somewhat similar, with almost 200 million tablet computers sold in 2013 (whole year). Android has a share of almost 62 percent, iOS about 36 percent, and Windows about 2 percent.

## Smartphones in use

Looking at smartphones in use today, the operating systems shares are ordered in the same way as sales, but differ significantly between the US and Europe.




Smartphone OS marked share in quarter 4, 2013; EU5 includes: France, Germany, Italy, Spain, and United Kingdom; Source of data: Kantar Worldpanel: ComTech Smartphone OS market share (% of smartphones) Region

[2] Source: Gartner research, http://www.gartner.com/newsroom/id/2665715
[3] Source: Data: Gartner research; Graphs: Wikipedia
4

## Mindomo

*Mind mapping*

Project Tools

Operating system(s): Android, iOS
Language: English
Price: free; Author: Expert Software Applications Srl
Alternative solutions: Simple Mind + (iOS) / Simple Mind Free (Android)

Collect all your thoughts (not only text, but also photos, URL's, audio, etc.) in a mind map and share them with your friends. Mindomo is easy to use and versatile in the incorporation of different data formats. It also allows to do interactive presentations and to work together with others on the same map.

## Trello

*Organize a project, keep track of progress, work on tasks collaboratively*

Project Tools

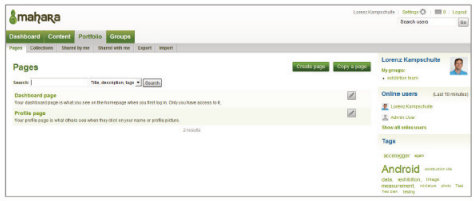
Operating system(s): Android, iOS, Browser
Language: English
Price: free; Author: Fog Creek Software
Alternative solutions: Hojoki - Project Management (Android/iOS)

Trello helps you to create the organizational structure of your project. Create lists, e.g. 'ToDo', 'Doing', 'Done', 'Things-to-remember', ... Create single tasks (called cards), add photos, checklists, mark them with different colors, schedule them, ... Structure the cards in the lists, according to project progress. Invite coworkers to participate in the board, to create their own tasks, to comment tasks and mark project progress in the tasks.

7

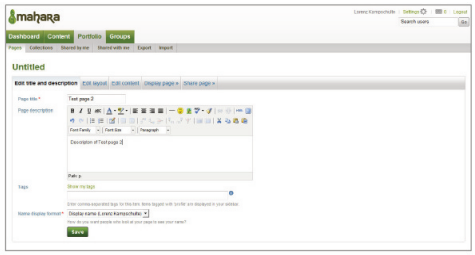
## HowTo: Create a Page

Go to [Portfolio] → [Pages]. You can create as many pages as you like.




To create a new page use the [Create page] button on the right. Dashboard and Profile page are installed on every profile. Dashboard page is your (customizable) start page when you log in, Profile page is the page you can design to introduce yourself to other Mahara users in your Setup.

When you start with a page:




Set a page title and a short description of the page. Use the blue tabs for further settings.

Set the layout to the style you need (basically how many columns, rows, ... you can change that later as well).

Add end edit content:

29

Impressions from the Web2.0 / App Guide. The full guide is available for download on www.irresistible-project.eu/index.php/en/resources.

## 2.1 Examples of using ICT in a learning unit

Whereas the Web2.0 / App Guide's aim is to present the large variety of tools available on the marked and to spark ideas of what could be used in general, the goal of this document is to give examples of how some of the tools could be integrated in a module. It presents three fictive illustrations on different topic areas:

- Unit on Plastics: Introduction to Plastics using Mahara
  (using an e-learning platform for collecting basic knowledge on plastics)
- Unit on Solar Energy: Defining the Best Position for a Solar Cell using different ICT Tools
  (employing different apps and online tools to optimize solar power)
- Unit on $CO_2$ Footprints: Calculating and Comparing $CO_2$ Footprints for Food and Travel
  (using different tools to track and calculate the (individual) $CO_2$ footprint)

To support the integration of ICT in the teaching modules developed within the IRRESISTIBLE project, the examples illustrate the core topics of the project, namely Responsible Research and Innovation (RRI), Inquiry Based Science Education (IBSE), gender issues and exhibitions. Table 1 gives a brief overview on the main aspects represented in the different examples.

In addition to these examples shown in this document, another use case on working with different app tools and integrating the results on the e-learning platform Mahara is documented in the Deliverable to the workshop, D4.2[2].

The document "Examples of using ICT in a learning unit - Additional ideas of how the tools could be integrated in the IBSE modules" is available for download on the IRRESISTIBLE website[3].

[2] http://www.irresistible-project.eu/index.php/en/resources/deliverables

[3] http://www.irresistible-project.eu/index.php/en/resources

Table 1: Indicating the core topics of the IRRESISTIBLE project being present in the following examples.

| Unit | Responsible Research and Innovation (RRI) | Inquiry Based Science Education (IBSE) | gender issues | exhibitions |
|---|---|---|---|---|
| **Unit on Plastics: Introduction to Plastics using Mahara** | Discussion on environmental issues of plastic, sustainability, bio-friendly alternatives, … | - | - | Presentation of the results gathered in the unit on the school website |
| **Unit on Solar Energy: Defining the Best Position for a Solar Cell using different ICT Tools** | - | Student groups are working on research tasks to find the best conditions for obtaining solar energy | - | - |
| **Unit on $CO_2$ Footprints: Calculating and Comparing $CO_2$ Footprints for Food and Travel** | The topic of $CO_2$ footprints instantly offers many starting points for RRI, e.g.: Knowing how they are calculate ('Science Education'), Regulations on $CO_2$ emissions ('Governance'), contributors to the problem ('Engagement'), … | Tracking individuals $CO_2$ footprint travelling to school for one week, comparing and discussing results | Comparison and discussion of the CO2e footprint of female/male eating behavior (group work2) | Presentation of core results as a poster |

# 3. CONCLUSIONS

The Web2.0 / App Guide offers a brief overview on existing tools to be used in the modules developed by the partners. If the tools selected do not offer the demanded functionality, the guide at least provides a starting point for searching better fitting gears. The introduction to Mahara, in combination with the test instance, allows to get used to working with a learner centered ePortfolio system, that could build the foundation for students to work on the modules.

The document “Examples of using ICT in a learning unit” offers ideas of how different tools could be practically integrated in the teaching modules, and how they could be used to target the core aspects of the IRRESISTIBLE project, namely Responsible Research and Innovation (RRI), Inquiry Based Science Education (IBSE), gender issues and student exhibitions.

# 4. ANNEX

## List of Web2.0/Apps listed in the current version of the guide

| | | | |
|---|---|---|---|
| 1 | Project Tools | Mindomo | Mind mapping |
| 2 | Project Tools | Trello | Organize a project, keep track of progress, work on tasks collaboratively |
| 3 | Project Tools | UTGreat | Interactive and collaborative video-whiteboard |
| 4 | Project Tools | Board cam Standard | Live notes as virtual 2nd layer on a running experiment |
| 5 | Project Tools | Papyrus Natural Note | Scetchbook style note app with easy export |
| 6 | Project Tools | Evernote | Remember everything: collect data, store it, and organize it. (sharing only with pro version) |
| 7 | Image Work | Lapse It | Time lapse & stop motion |
| 8 | Image Work | 1 Second Everyday | Imagine a movie that includes every day of the rest of your life |
| 9 | Image Work | PicsArt | All in one image processing app |
| 13 | Measuring | Photo Ruler ABC | Measure your surroundings |
| 10 | Measuring | OSMTracker | Track your way |
| 11 | Measuring | iMetalBox free | Measurement tool box |
| 12 | Measuring | Accelogger | Use the internal acceleration sensors of you smart device |
| 14 | Measuring | Oscilloscope | Dual channel oscilloscope w/o extra hardware |
| 15 | Mobile Office | Quickoffice (Google Version) | A free mobile office solution that works |
| 16 | Mobile Office | CamScanner - Phone PDF Creator | Smart and intelligent document administrator |
| 17 | Mobile Office | UPAD lite | Give your notes a new level |
| 18 | Collaborative work | Google Docs | Simultaniously working on the same (web-)documents |
| 19 | Collaborative work | Mahara ePortfolio | Web2.0 in a nutshell: ePortfolio system plus safe social network |
| 20 | Knowledge | Wikipedia Mobile | Wikipedia easily accessible in your pocket |
| 21 | Knowledge | Merck PSE | The periode table, presented in a nice way |
| 22 | Knowledge | Formulas Free | All math fomulas in your pocket |
| 23 | Knowledge | Physics Notes | Physics formulary and text book |
| 24 | Knowledge | Sky Map | The universe in your pocket |
| 25 | Tools | Quick Graph | Capable scientific graphing calculator |
| 26 | Tools | Universal converter free | Easy to use unit converter |
| 27 | Tools | i-nigma | The most widely used mobile barcode reader in the world! |
| 28 | Exhibition | QR Code Generator | Greate various QR-codes (www.goqr.me) |
| 29 | Exhibition | Open Exhibits PLAYER | Author/Edit multitouch, multi-user exhibits in CML, GML and CSS (www.openexhibits.org) |
| 30 | Exhibition | Open Exhibits SDK | Develop multitouch, multi-user exhibits and components (www.openexhibits.org) |
| 31 | Add-On / Knowledge | Khan Academy | Leraning while watching |
| 32 | Add-On / Measuring | SPARKvue | Real-time sensor-based data collection |


# The Web2.0 / App Guide

## Ideas for tools that could be used in the IBSE modules

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# Content

# Introduction

The aim of this guide is to offers you a brief overview of tools that might be useful for Inquiry Based Science Education (IBSE). In total, there's more than two million apps around, so it's not the problem that the app you are searching for is not out there, the challenge is to find it. If you ever used a smartphone, you will know that apps have very different qualities, and prices. Our goal for this guide was to find useful apps for the different tasks of IBSE. The main tasks were defined as

- Project organization
- Searching for Knowledge
- Measuring data
- Processing data
- Taking notes and working on data
- Sharing and publishing results

For each section, we searched tools that satisfied the criteria we defined beforehand:

- The tool should work
- The tool should be available on both major operating systems (or at least a similar app should be available)[1], so you could use a mixed set of handhelds in the classroom. Another option would be a web based tool, being accessible with any device's web browser.
- The tool should be free (although apps usually are not really expensive, we feared the effort – if you use student's own phones – of making your (underage) students buy an app for)
- The tool should not be cluttered with nasty advertisements. Although we see that programmers need some revenue to live from, it should not hinder you using the app. Thus you'll find several apps showing ads, but in a decent way.

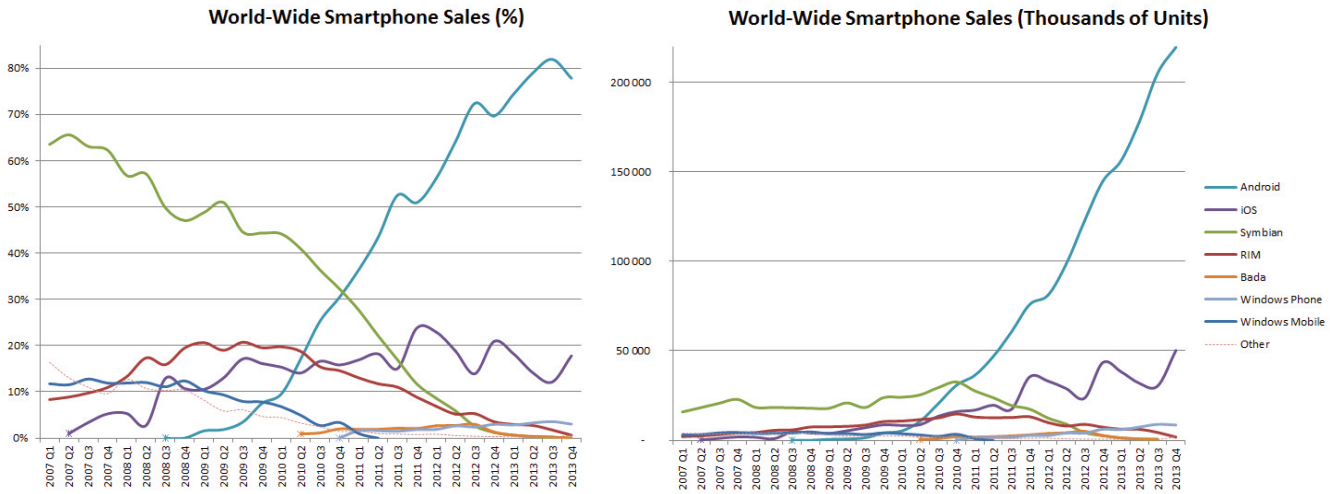
Since the pace of the app marked is incredible fast, this guide is only to see as a snap-shot from early 2014. Some tools will stay for quite a while; others might disappear in a few months. And new, better ones will show up. But in general, if you know from this guide that there is a tool for this or that, it will be easy to find a replacement.

In the following, a brief listing of relevant facts and figures on mobile devices:

[1] Some apps with the same name, even from the same author, have greatly varying functionality in the version for different operating systems. Check out or at least have it in mind when setting up the tasks for your students…

## Smartphone sales

In 2013, almost 1 billion of smartphones was sold worldwide, a growth of 42.3 percent from 2012. Android is by far the most widely used operating system with over 78 percent of smartphones sold in 2013 running Android, followed by iOS with a 16 percent market share, and Windows Phone reaching three percent.[2]

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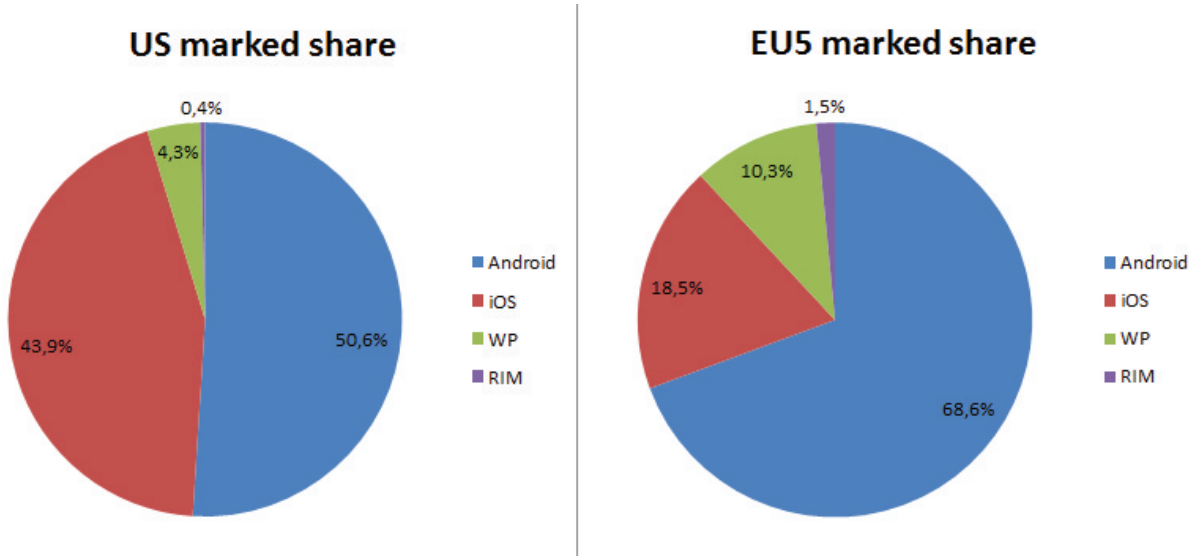


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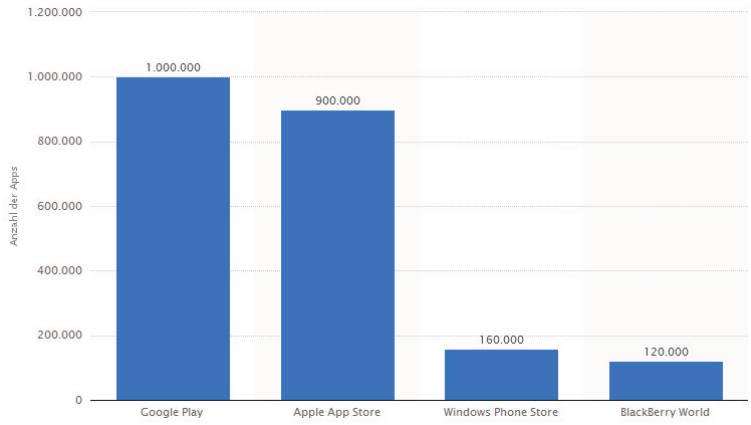
[2] Source: Gartner research, http://www.gartner.com/newsroom/id/2665715
[3] Source: Data: Gartner research; Graphs: Wikipedia

## Number of apps offered for the different OS

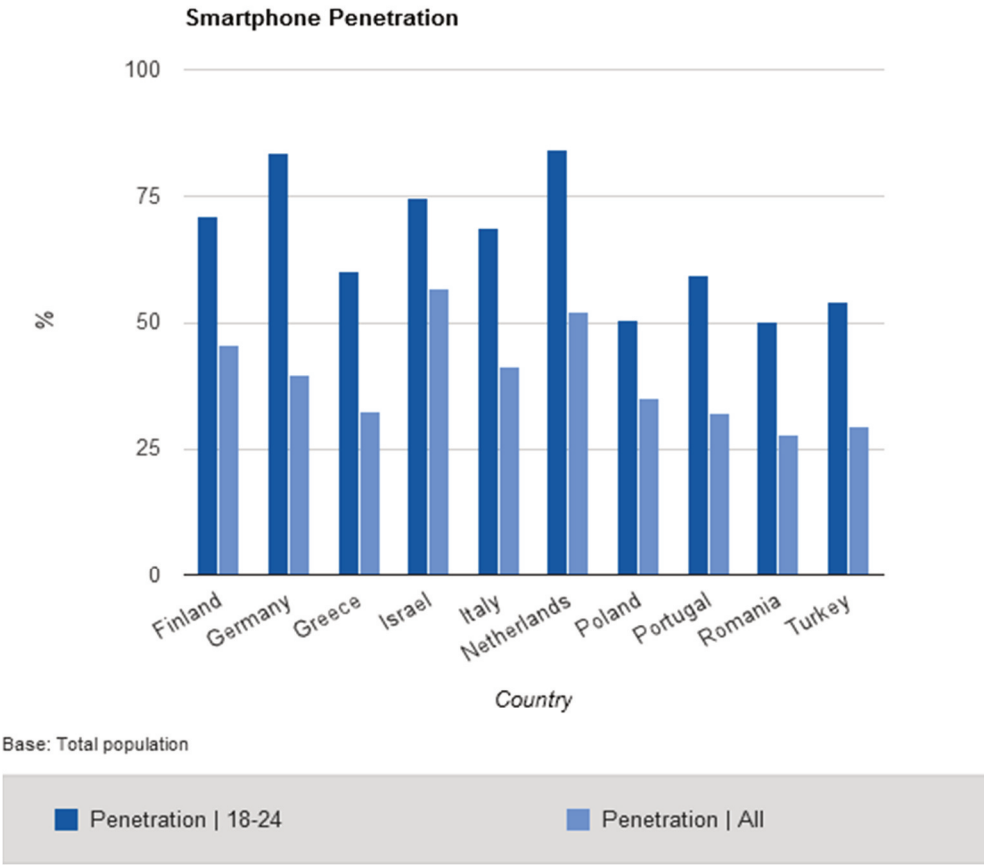
More than 2 million apps are accessible through the official app stores.




Apps offered in the official stores Google Play (Android), Apple App Store (iOS), Windows Phone Store (WP), and Blackberry World (RIM). Data of July 2013; Source and graph: Statista.

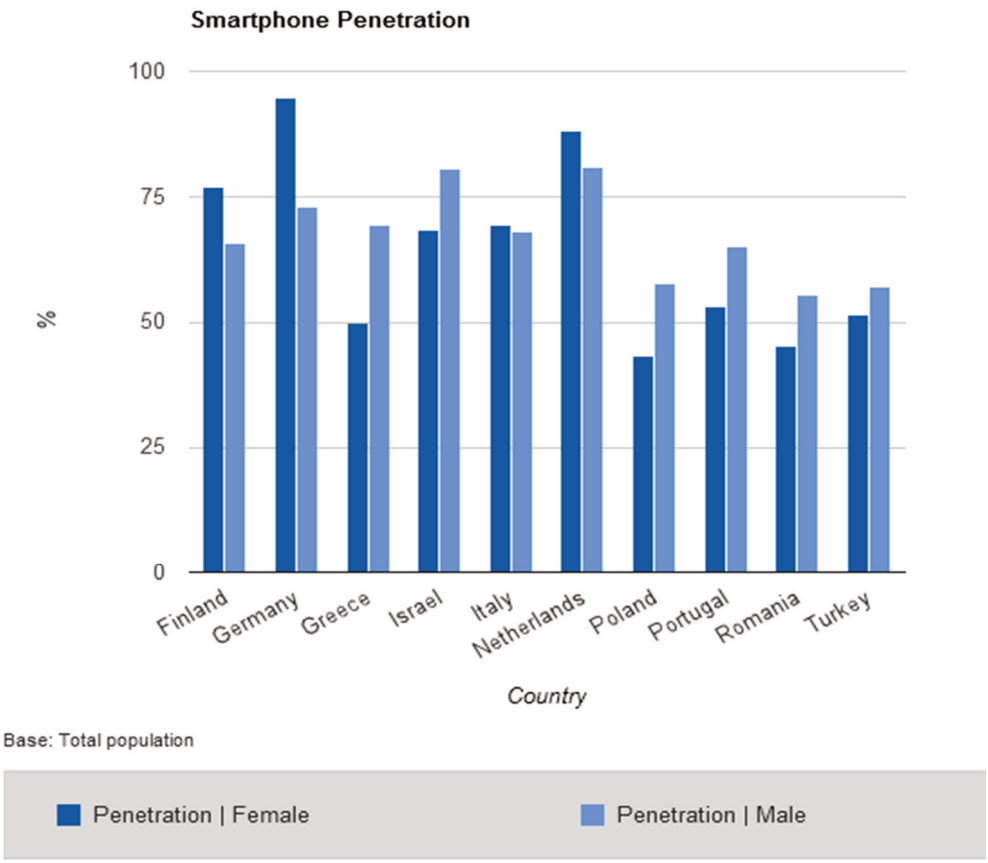
## Smartphone users

Europe has an average general smartphone penetration of less than 50 percent, but in the age group closest to that relevant for our project the penetration is about 60 percent, i.e. at least every second student owns a smartphone. The penetration rate varies between the countries, age groups and gender. Here are a two graphs made from Google's Our Mobile Planet report[4], all dated 2013.




[4] http://think.withgoogle.com/mobileplanet/en/ - you can create your own custom made data charts!

Smartphone penetration by gender (Data from Google's Our Mobile Planet report as well):




## App catalogue

The following section offers you the core facts for each tool we chose: The title, the operating system, price, author, a very brief description of what it is, and a few screenshots for you to have an idea how the tool looks like. Where applicable, we also named an alternative solution for use, sometimes with a different operating system, sometimes a different tool with a similar functionality. In general, the app stores (with different success) offer you further options with tools that should have comparable functionality.

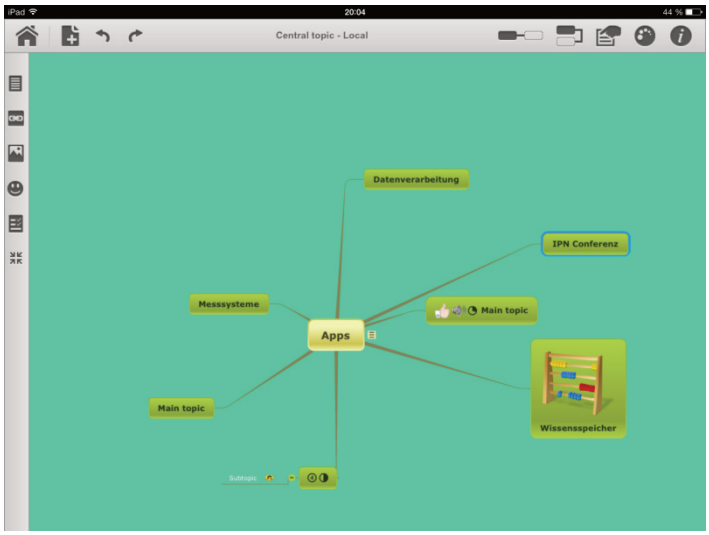
A little hint for Android users: When searching the Google Play Store using your Android device, it'll only show you the apps working on your device. If you search for tools in general, use your browser to get the full program.

# Mindomo

*Mind mapping*

Operating system(s): Android, iOS
Language: English
Price: free; Author: Expert Software Applications Srl
Alternative solutions: Simple Mind + (iOS) / Simple Mind Free (Android)

Collect all your thoughts (not only text, but also photos, URL´s, audio, etc.) in a mind map and share them with your friends. Mindomo is easy to use and versatile in the incorporation of different data formats. It also allows to do interactive presentations and to work together with others on the same map.



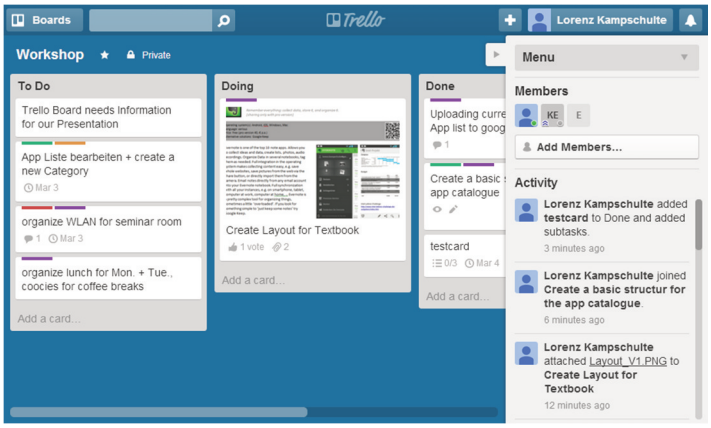



# Trello

*Organize a project, keep track of progress, work on tasks collaboratively*

Operating system(s): Android, iOS, Browser
Language: English
Price: free; Author: Fog Creek Software
Alternative solutions: Hojoki - Project Management (Android/iOS)

Trello helps you to create the organizational structure of your project. Create lists, e.g. ‘ToDo’, ‘Doing’, ‘Done’, ‘Things-to-remember’, … Create single tasks (called cards), add photos, checklists, mark them with different colors, schedule them, … Structure the cards in the lists, according to project progress. Invite coworkers to participate in the board, to create their own tasks, to comment tasks and mark project progress in the tasks.

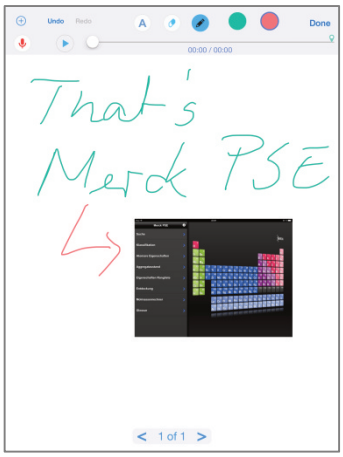


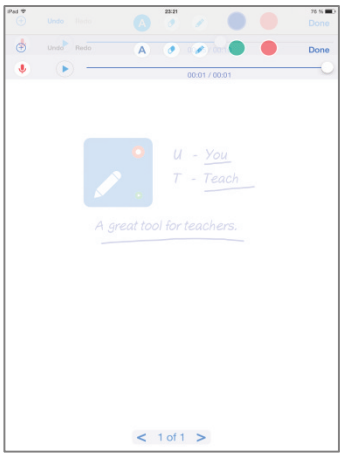
# UTGreat

*Interactive and collaborative video-whiteboard*

Operating system(s): Android, iOS
Language: English
Price: free; Author: Yuansheng Chen
Alternative solutions: Papyrus Natural Note (Android)

UTGreat is a tool for creating and sharing whiteboard content. You can create whiteboards containing sketches, text, photos and even videos. Sharing them with other UTGreat users is easily done by creating a link or QR-code.



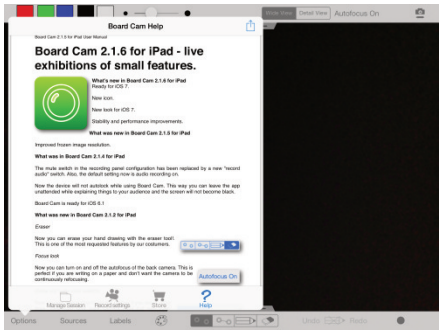


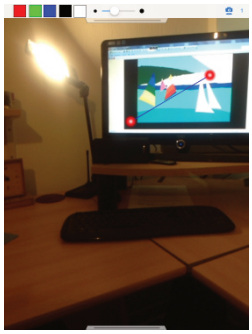

# Board cam Standard

*Live notes as virtual 2nd layer on a running experiment*

Operating system(s): iOS
Language: English
Price: free; Author: Juan Luis Herrera Cortijo
Alternative solutions: -

Board Cam allows you to make notes directly on the video recorded by the camera. This allows for instance to do an experiment with a ball rolling down a slope and stopping at different positions at each run. You can mark the end position and see how they differ. The screen can be transferred to a projector, so students can follow even in a classroom.



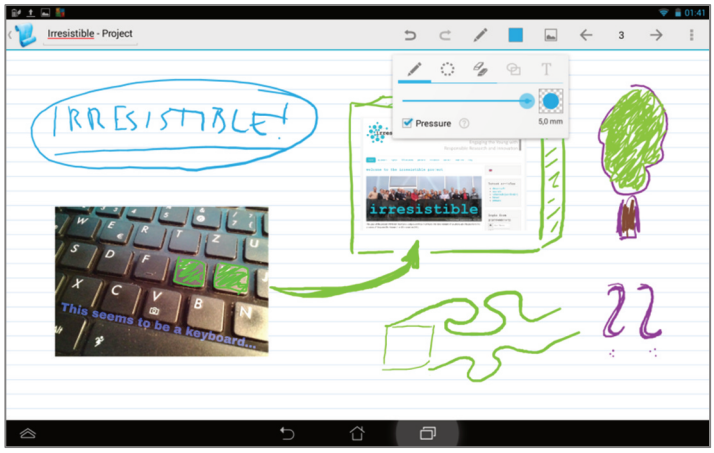



# Papyrus Natural Note

*Scetchbook style note app with easy export*

Operating system(s): Android
Language: English
Price: free; Author: Steadfast Innovation, LLC
Alternative solutions: UPAD lite (iOS)

Papyrus Natural Note is an easy to use App for sketching and creating simple collages, include photos (+ cut, rotate, …). Create different scetchbooks with several pages. Very acute finger / pen pressure recognicion allows elegant sketching (depends also on the touchscreen of your device). Export single pages or whole sketchbook in .pdf, .png or .jpg format



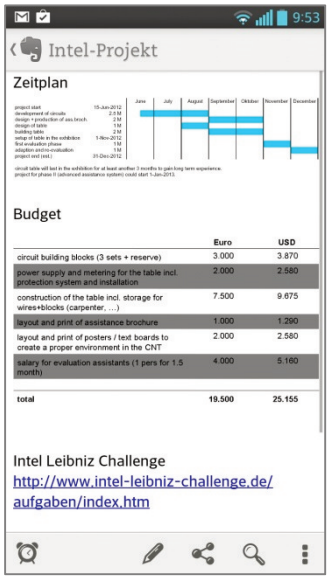



# Evernote

*Remember everything: collect data, store it, and organize it.*
*(sharing only with pro version)*

Operating system(s): Android, iOS, Windows, Mac
Language: various
Price: free (pro version 40,-€ p.a.); Author: Evernote
Alternative solutions: Google Keep (Android/iOS)

Evernote is one of the top 10 note-taking apps. Allows you to collect ideas and data, create lists, photos, audio recordings. Organize Data in several notebooks, tag them as needed. Full integration in the operating system makes collecting content easy, e.g. save whole websites, save pictures from the web via the share button, or directly import them from the camera. Email notes directly from any email account into your Evernote notebook. Full synchronization with all your instances, e.g. on smartphone, tablet, computer at work, computer at home, … Evernote is a pretty complex tool for organizing things, sometimes a little ‘overloaded’. If you look for something simple to ‘just keep some notes’ try Google Keep.

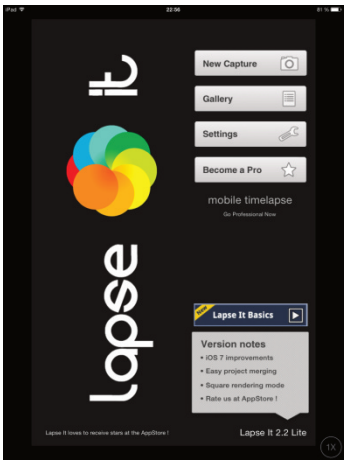



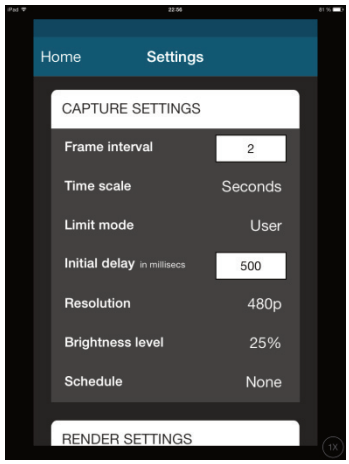
## Lapse It

*Time lapse & stop motion*

Operating system(s): Android, iOS
Language: English
Price: free; Author: Interactive Universe
Alternative solutions: Droid Timelapse (Android)

Lapse It is a tool to create time lapse or stop motion movies. Take photos every few seconds, and render them to a movie. So you can follow a 1h sunrise in 3 minutes. Or you can investigate the movement of a sunflower head during a sunny day. Or, with lots of time (and an extra smartphone) follow seedlings growing. If you don't want to use your phone for longer term experiments, theres a lot of webcam based time lapse tools for your computer, or have a look at your photo camera, quite a few have a time lapse function integrated (see e.g. en.wikipedia.org/wiki/Time-lapse_photography for a start)

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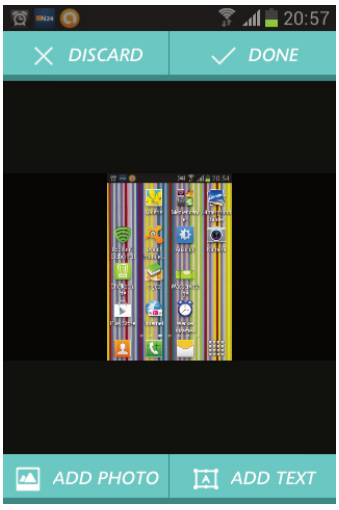
## 1 Second Everyday

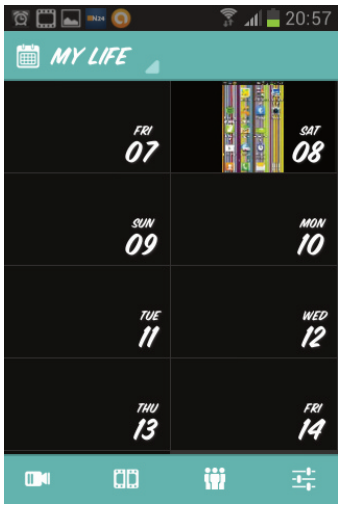
*Imagine a movie that includes every day of the rest of your life'*

Image Work

Operating system(s): Android, iOS
Language: English
Price: free (for 1 Month, then 0.89€); Author: Cesar Kuriyama
Alternative solutions: 1 Second Daily Cam (iOS)

Track processes over a longer period of time: Trees getting green in spring, or track the view out of your window over a full season. This App allows you to create multiple timelines in a Video that you can share and save via Google Drive.



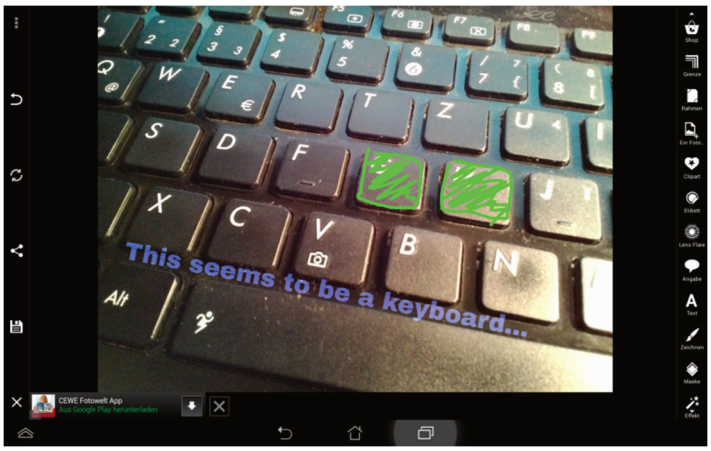



## PicsArt

*All in one image processing app*

Operating system(s): Android, iOS
Language: various
Price: free; Author: PicsArt
Alternative solutions: Pixlr Express (Android/iOS)

PicsArt is one of the best photo-editing programs for smartphones and tablets, offering a large number of features. Create sketches from scratch, use a photo and rework it, include it in a collage. Share your work in various ways, inside the community or via Twitter and Facebook etc. The camera module included allows to record an interval series of photos, e.g. for tracking a chemical reaction on minute scale and comparing the different states.

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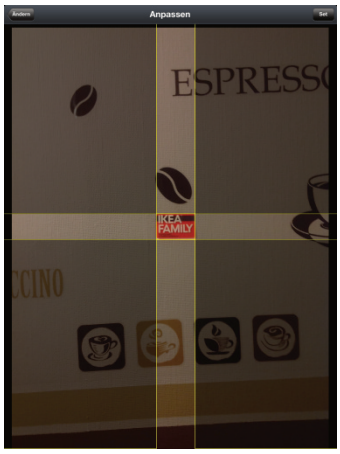
Measuring

## Photo Ruler ABC

*Measure your surroundings*

Operating system(s): iOS
Language: English
Price: free; Author: QL Software
Alternative solutions: Camera Ruler / ON 2D Measure (both Android)

With Photo Ruler ABC you can easily measure dimensions from mm to m scale. It works by including a reference object like a coin, a CD/DCD or DIN A4 paper, into the photo (on the image plane to be measured). The photograph is then referenced to that object and you can measure dimensions. Great for documenting different sized objects, e.g. beetles found on a field trip, or tracking the growth of plants.

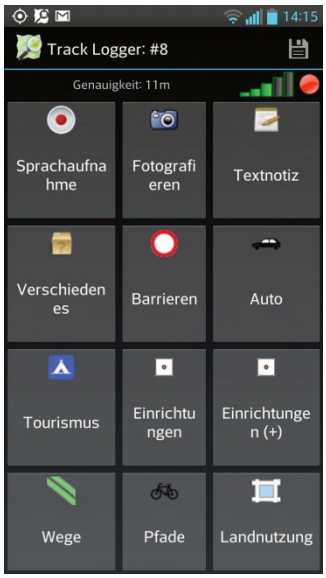


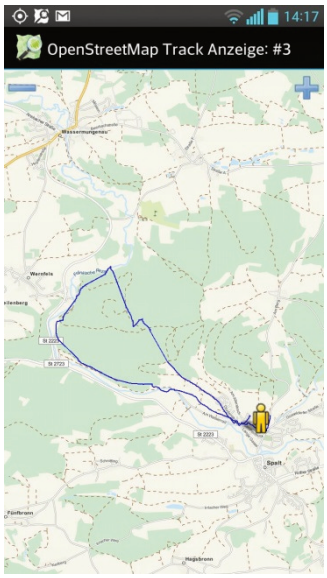

# OSMTracker

*Track your way*

Operating system(s): Android
Language: English
Price: free; Author: Nicolaus Guillaumin
Alternative solutions: My Tracks / GPS-Tracks (both Android/iOS)

With OSMTracker you can log a route you have taken with GPS, e.g. while hiking, cycling, or on a scientific field trip. OSM tracker allows you to add points of interest (PoI) alongside the track, e.g. text messages, markers, photos, audio recordings, ... The recorded tracks can be shown in the app, or exported in .gpx format, allowing the further work on them with a multitude of programs (e.g. Google Maps, Google Earth, and many add-ons that build on them).






# iMetallBox free

*Measurement tool box*

Operating system(s): iOS
Language: English
Price: free; Author: Tue Nguyen Minh
Alternative solutions: Smart Tools Werkzeuge (Android)

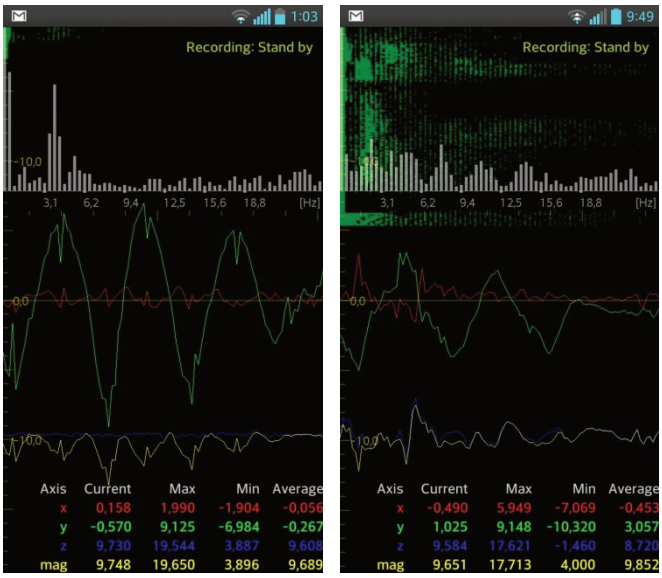
iMetalBox is a tool box including different measuring devices build on the sensors of your smartphone. iMetalBox includes a Flashlight, Stoppwatch, Spirit Level, Ruler, Protractor, and a Compass. Smart tools for Android is a comparable collection (the full collection is a pay app, but you can download all tools as stand alone measures for free). Be aware that the measuring results are highly influenced by the type of smartphone you use (i.e.the sensors and electronics therein).


# Accelogger

*Use the internal acceleration sensors of you smart device*

Operating system(s): Android, iOS
Language: English
Price: free; Author: Sora Takayama
Alternative solutions: Sensor Kinetics / Sparkvue (both Android/iOS)

Accelogger is a tool to log the signals of the accelerometers build in your smartphone. Accelogger reads out the accelerations in all three spatial directions (x,y,z in m/s²), shows them in different ways on the screen and writes them alongside with a time stamp to a simple text file on the phone. With this app you could e.g. track the maximum acceleration of elevators, vibrations of a car on different roads, or your walking frequency. The App Sensor Kinetics shows more results derived from the accelerometer and other sensors in your phone, like gyroscpoe, magnetometer, rotation, and light sensor. Data export is possible with Pro version only (0,76€). Sparkvue is usually meant to be used with external sensors, but works with internal sensors as well (iOS is free).



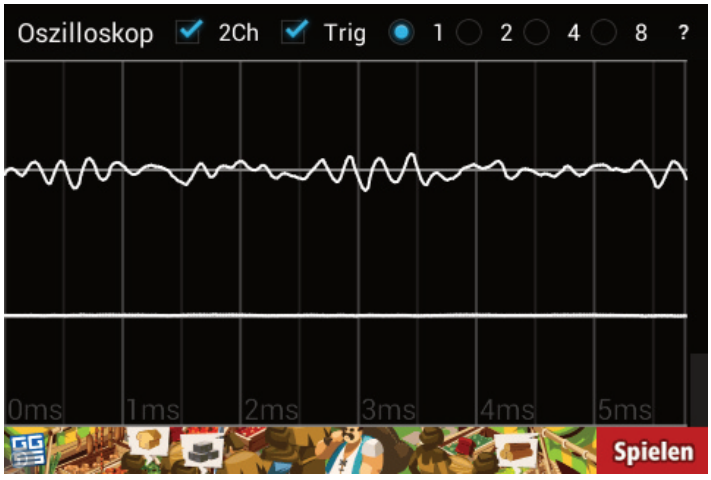

# Oscilloscope

*Dual channel oscilloscope w/o extra hardware*

Measuring

Operating system(s): Android
Language: English
Price: free; Author: UberApp
Alternative solutions: iMSO Oscium (iOS, needs additional hardware, ~ 270 €)

This App is a simple dual channel storage oscilloscope. It uses either the internal microphone or some device (microphone) conected to the headphone/mic plug as input. Combine it with a function generator (e.g. the app FuncGen Signal Generator (Crescendo)) and/or a Fourier spectrum analyzer (e.g. the app FFT Spectrum Analyzer (UberApp)) and you'll have an easy set up for simple sound experiments. But be aware that smartphone speakers and microphones are far from perfect tools, especially due to signal transformations build in to increase speech quality...



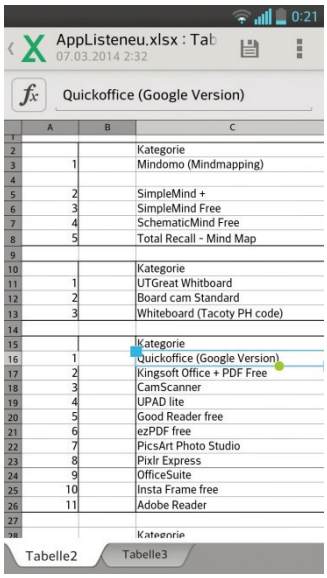
# Quickoffice (Google Version)

*A free mobile office solution that works*

Mobile Office

Operating system(s): Android, iOSvarious
Language: various
Price: free; Author: Google Inc
Alternative solutions: Office Suite (Android/iOS)

A free, simple and working office solution for smartphones and tablets. Although more special functionalities of Microsoft Office are not supported, it allows you to work with general documents and shows standard formatted tables, text and slides mostly correct (which many mobile office versions don't do). Easy sharing and collaborating due to synchronization and sharing functions of Google Drive.


# CamScanner - Phone PDF Creator

*Smart and intelligent document administrator*

Mobile Office

Operating system(s): Android, iOS
Language: various
Price: free (pro version 4,49 € per month); Author: IntSig Information Co.,Ltd
Alternative solutions: Foxit PDF Camera + Foxit MobilePDF (Android)

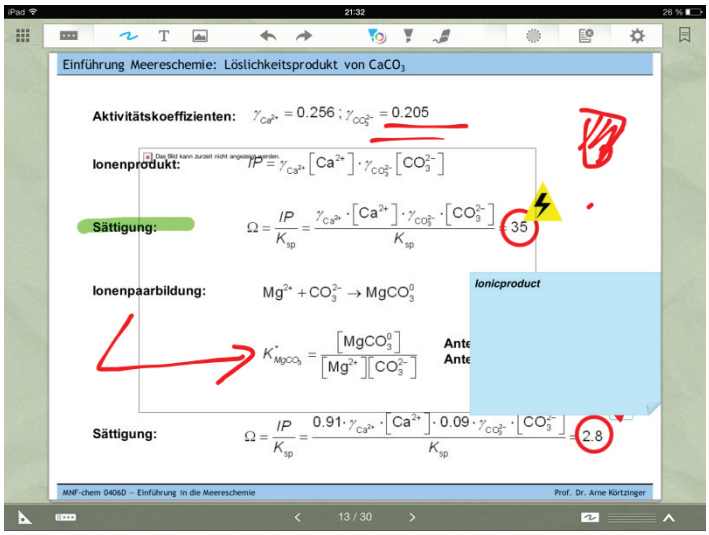
Scan documents, whiteboards, blackbords, pictures, ... with your smartphone camera and directly create .pdfs out of it. Nice tool for cutting the page area and increasing readablity. The free version can export/share as .jpg without, or as .pdf with a watermark on the lower end of the page. The OCR function allows to search the scanned .pdfs, although not perfect. Automatic upload to different Cloud spaces, multiple ways of sharing the documents and comments, with the possibility of others commenting the shared documents in the same document.

# UPAD lite

*Give your notes a new level*

Operating system(s): iOS
Language: English
Price: free (up to 5 documents, pro version 4,49 €); Author: PockeySoft
Alternative solutions: Papyrus Natural Notes as notepad, Foxit MobilePDF as pdf annotation tool (both Android)

The main part of UPAD is a notepad, for taking text and sketch notes. Good handwriting recognition. Also allowes to annotate PDF and to decorate photos. Export of pdf to different cloud services.



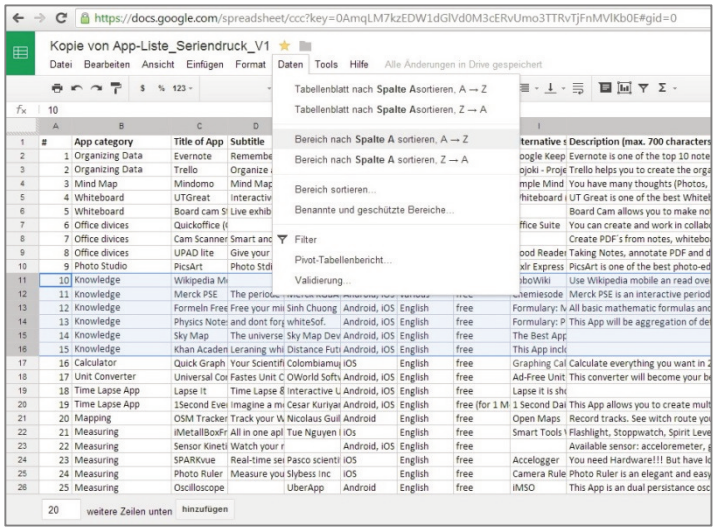

# Google Docs

*Simultaneously working on the same (web-)documents*

Collaborative work

Operating system(s): Browser
Language: various
Price: free; Author: Google Inc.
Alternative solutions: Zoho Office Suite (www.zoho.com)

Easy to use office applications accessible via web browser (Chrome works best). Good integration and accessablility from mobile systems, simple sharing, 15Gb of free Cloudspace. With Google Forms it's easy to create (online) questionnaires and analyze them. Teams can collaboratively work on the same document at the same time. Gmail account is needed.



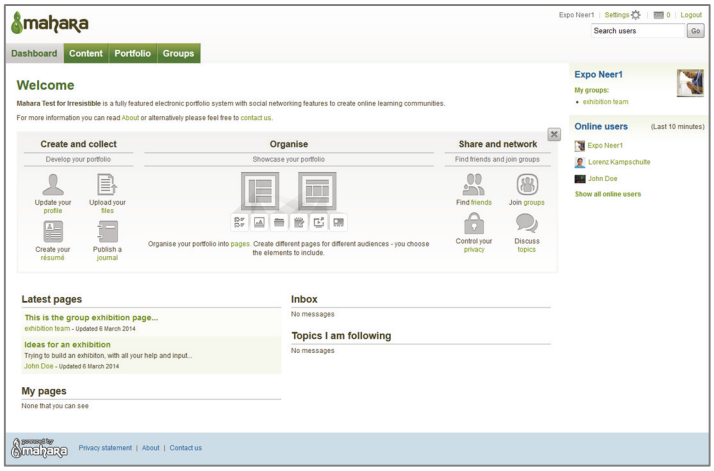
# Mahara ePortfolio

*Web2.0 in a nutshell: ePortfolio system plus safe social network*

Collaborative work

Operating system(s): Browser, Upload tools for Android (MaharaDroid) and iOS (PortfolioUP!)
Language: various
Price: free; Author: Mahara Open Source Community
Alternative solutions: -

Mahara is an ePortfolio system that is explicitly developed as learner centered system to form a Personal Learning Environment (in contrast to Learning Management System (LMS) like Moodle). It offers a dazzling array of functionalities, with the core being an ePortfolio system and a shielded social network with tools as journals (private/ internal), a blogging tool, easy to program (drag-and-drop) web pages (privat/ internal/ external), collaborative work pages, a resume builder, ... Mahara can be used as stand-alone system or be integrated in a larger network, e.g. with it's 'sister' application Moodle. It usually needs a Linux Server (Ubuntu, Debian), but can also be run on most shared webhosting and Windows systems.

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# Wikipedia Mobile

*Wikipedia easily accessible in your pocket*

Knowledge

Operating system(s): Android, iOS
Language: various
Price: free; Author: Wikimedia Foundation
Alternative solutions: LoboWiki (Android)

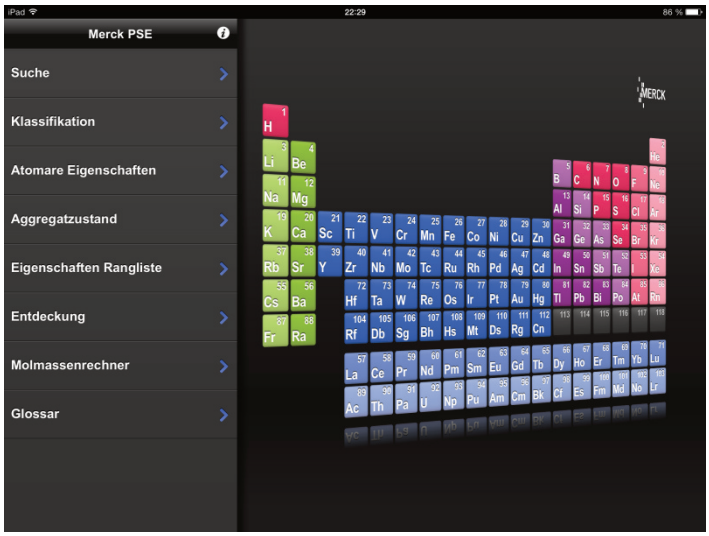
Use Wikipedia mobile an read over 20 million articels. Save articles to read later offline, search articles nearby. Share articles (links) in various ways. On aged phones, the app is much faster than using a browser.


## Merck PSE

*The periodic table, presented in a nice way*

Operating system(s): Android, iOS
Language: various
Price: free; Author: Merck KGaA
Alternative solutions: Chemisode (iOS)

Merck PSE is an interactive periodic table with a clean and friendly design. Besides all relevant information usually part of a periodic table, the app includes element features, images, history of discovery, melting and boiling point – you even have a view of the PSE indicating the state of matter of each element at a given temperature. Further the app offers an integrated molar mass calculator. All content is stored within the app, after download no internet connection necessary (due to legal restrictions this app is named EMD PTE in North America).

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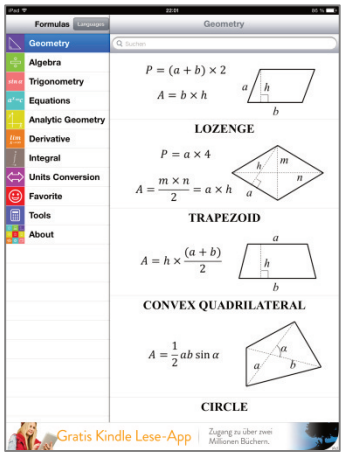
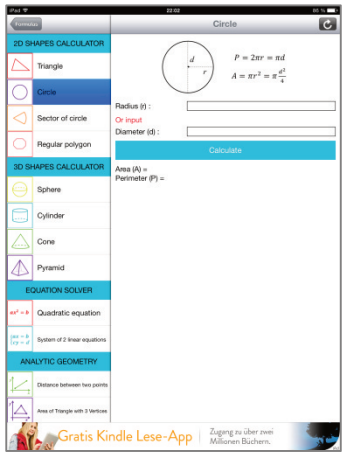
## Formulas Free

*All math fomulas in your pocket.*

Operating system(s): Android, iOS
Language: English
Price: free; Author: NSC Co.
Alternative solutions: Formulary: Math Free (Android/iOS)

The app Formulas Free contains all basic mathematic formulas and many helpful gadgets like calculating the surface area or solving roots/equations. It also includes a simple unit converter. You can share every formula with friends via email, massage or facebook.



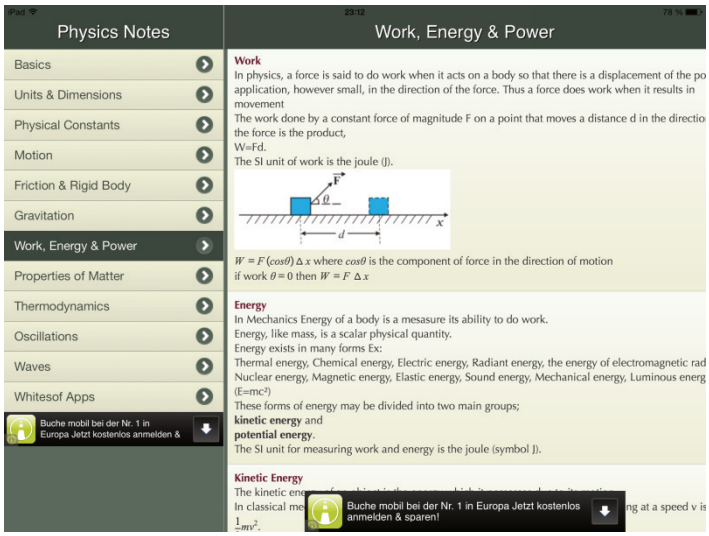

# Physics Notes

*Physics formulary and text book*

Knowledge

Operating system(s): Android, iOS
Language: English
Price: free; Author: whiteSof.
Alternative solutions: Formulary: Physics Free (iOS)

This app is an aggregation of definitions and formulas in basic physics knowledge, somewhere between fomulary and text book. Part 1 contains e.g. basics of physics, units, dimensions, physical constants, classical mechanics, ... Part 2 (separate app 'Physics Notes 2') contains e.g. electricity, magnetism, electromagnetic waves, ray optics, ...



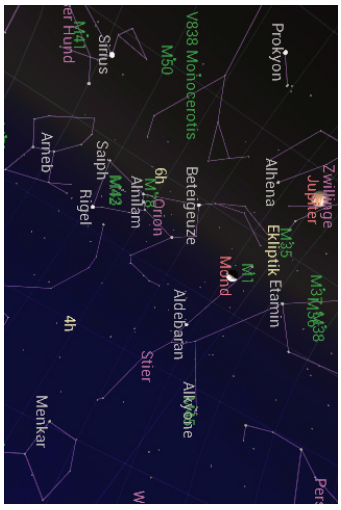

# Sky Map

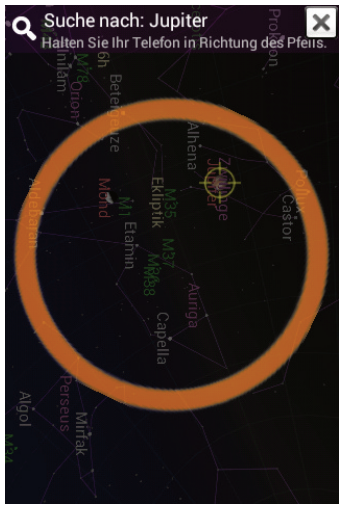
*The universe in your pocket*

Knowledge

Operating system(s): Android, iOS
Language: English
Price: free; Author: Android: Sky Map Devs, iOS: Mobius Entertainment
Alternative solutions: -

The app offers you navigation through the night sky. It works in two modes: Point your phone to any star or constellation, and it will offer you the solution on the screen. Or search for a star or constellation in the menu, and let you guide to the object of desire.



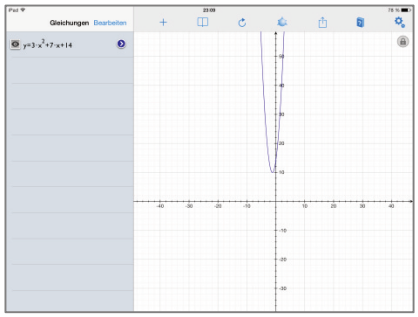



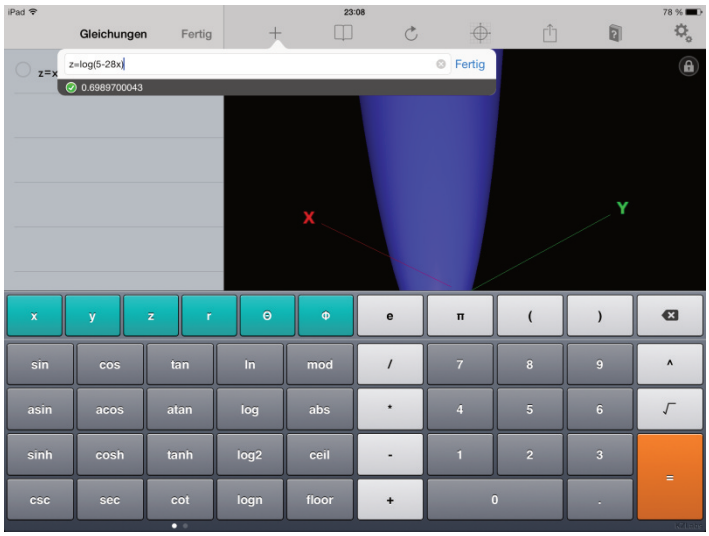
# Quick Graph

*Capable scientific graphing calculator*

Operating system(s): iOS
Language: English
Price: free; Author: Colombiamug
Alternative solutions: Graphing Calculator (Android)

This scientific graphing calculator offers 2D and 3D equation plotting with wireframe and solid visualization. Supports cartesian, polar, cylindrical and spherical coordinate systems. Includes a library for commonly used equations.






# Universal converter free

*Easy to use unit converter*

Tools

Operating system(s): Android, iOS
Language: English
Price: free; Author: OWorld Software
Alternative solutions: Ad-Free Unit-Converter (iOS)

Universal Converter free is a clearly desiged and easy to use app for converting various units. The free app includes e.g. mass, speed, volume, distance, time, temperature.


## i-nigma

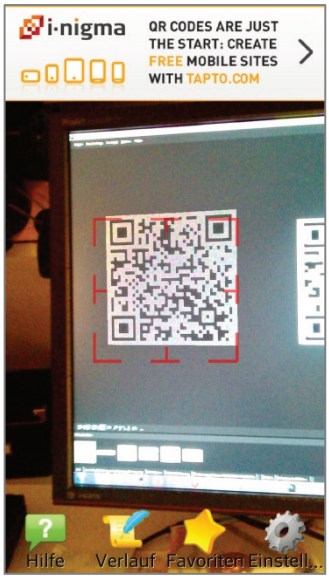
*The most widely used mobile barcode reader in the world!*

Tools

Operating system(s): Android, iOS
Language: English
Price: free; Author: 3GVision
Alternative solutions: Barcode Scanner (Android)

Barcode reader for various code formats, e.g. 1D and 2D codes like QR, DataMatrix, EAN 13 and UPC . Works fast and also pretty well when codes are in bad condition or at low light.

[referring the ad shown here: Tapto.com offers a system that allowes to easily create simple mobile sites accessible through QR codes for free. This might also be an solution for use in your exhibition project. For details visit www.tapto.com.]

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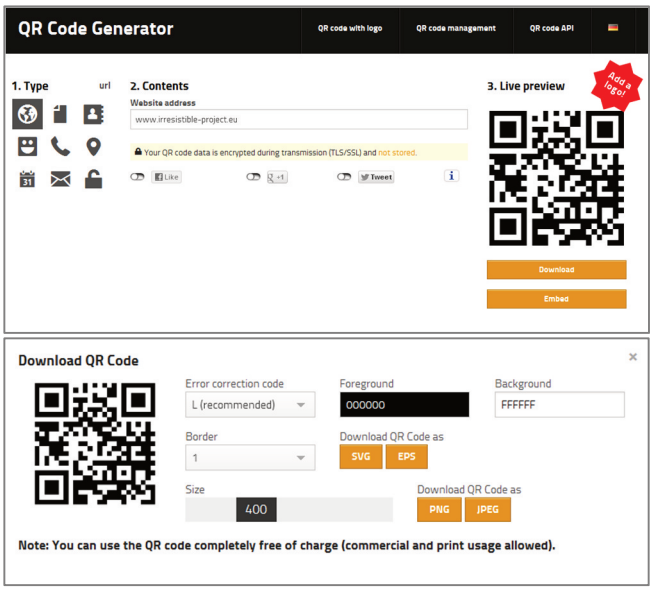
## QR Code Generator

*Greate various QR-codes (www.goqr.me)*

Exhibition

Operating system(s): Browser
Language: English
Price: free; Author: ARSAVA GmbH & Foundata GmbH GbR
Alternative solutions: www.i-nigma.com/CreateBarcodes.html

Create 2D barcodes online. Offers different content formats, e.g. text, URL, vcard, telephone, geolocation, WLAN access data, ... Create codes with a resolution of up to 1000x1000 Pixel, download as .png, .jpg, .svg, .eps files. Different colors are possible, unlimited use, no ads.



# Open Exhibits PLAYER

Exhibition

*Author/Edit multitouch, multi-user exhibits in CML, GML and CSS (www.openexhibits.org)*

Operating system(s): Windows, Mac OS
Language: English
Price: free; Author: Ideum
Alternative solutions: -

Edit and adapt a multitouch surface without deeper programming skills. The OE Player works comparable to a web browser interpreteing XML-based mark-up language and cascading style sheets (CSS). By changing the XML files you can adapt the content, by adjusting the CSS files you can change the look. (OE Player requires Adobe AIR and Windows OS)


# Open Exhibits SDK

Exhibition

*Develop multitouch, multi-user exhibits and components (www.openexhibits.org)*

Operating system(s): Windows, Mac OS
Language: English
Price: free; Author: Ideum
Alternative solutions: -

The OpenExhibits Software Development Kit (SDK) allows you to easily program your own multitouch application. The Kit is written in ActionScript. Adobe Flash and Adobe AIR are supported. The OE SDK allows you to develop in the IDE of your choice, but Open Exhibits officially supports the following IDEs: Flash Professional CS5+, FlashDevelop, Flash Builder.

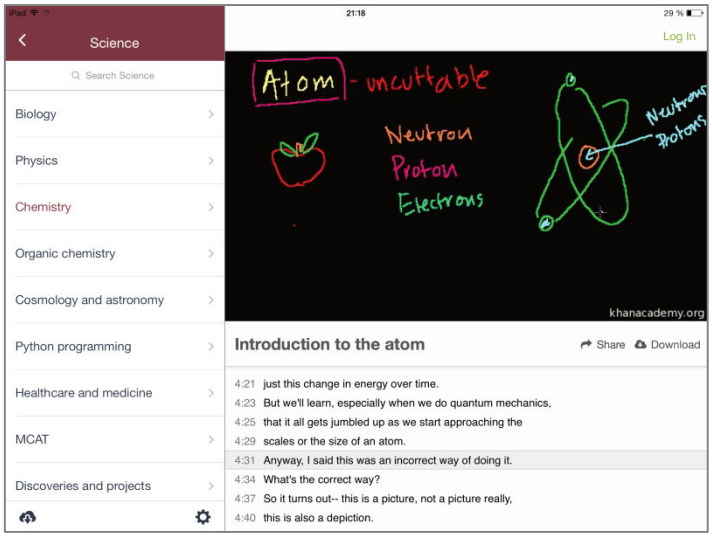
# Khan Academy

*Learning while watching*

Add-On / Knowledge

Operating system(s): Android, iOS
Language: English
Price: free; Author: Distance Future
Alternative solutions: -

This app offers a huge collection of video lectures. Topics are e.g. mathematics, science, economics, humanities, etc. Most lectures include experiments, notes, and pictures.



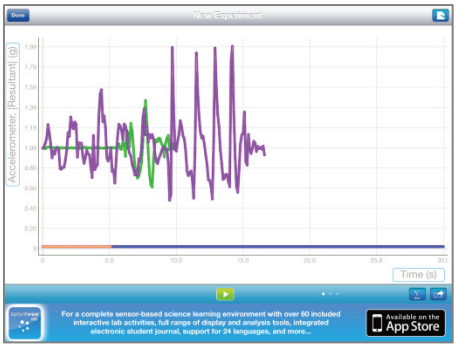

# SPARKvue

*Real-time sensor-based data collection'*

Add-On / Measuring

Operating system(s): iOS
Language: English
Price: free; Author: Pasco scientific
Alternative solutions: -

Internal sensors right away, lots of external sensors for measuring various variables. Have a look at: http://www.youtube.com/watch?v=rnhKwUVJmKw




# Short Introduction Mahara

This really should just be a very brief introduction to use it in the Web2.0/App Workshop. All information you need you'll find on www.mahara.org. Also, there are many national groups supporting the system and offering tutorials in your language. And you can find a lot of detailed video tutorials on YouTube.

## What is Mahara?

Mahara is an ePortfolio system that is explicitly developed as learner centered system to form a Personal Learning Environment (in contrast to Learning Management System (LMS) like Moodle). It offers a dazzling array of functionalities: The core components are an ePortfolio system to present, share and exchange information, including a full file repository with upload possibilities from mobile devices. The second large part is a shielded social network with tools as journals (private/internal), blogs, forums, easy to build web pages (private/ internal/ external), collaborative work pages, a resume builder, and many more. All the content is easily placed on the pages by drag-and-drop, combining internal (Mahara portfolio) and external (web) content on the same pages. Even external blogs can be embedded on internal pages using RSS feeds. Mahara scales nicely on different systems, so you can work on the web interface from your personal computer, laptop, tablet, and smartphone.

Mahara can be used as stand-alone system or be integrated in a larger network, e.g. with its 'sister' application Moodle. It nicely integrates in Moodle, you can e.g. use the same login accounts and manage them in Moodle, and you can directly link from Moodle pages to Mahara pages.

The System Requirements are not immense, but have in mind that traffic and thus machine load scales with the numbers of users. The Mahara standard setup is to run it on an Apache web server installed on a Linux system (e.g. Ubuntu, Debian), it also needs a database (Postgres or MySQL) installed for managing user data and content. Running it on a separate machine will give you the best performance. But it also works on shared webhosting, and on Windows and MAC operating systems. See Mahara.org for details. The design can be widely customized.

## Names and Definitions

Artefacts: all data created and/or uploaded to Mahara are called artefacts

View: a view is a collection of artefacts, e.g. a journal, a page, a blog entry, …

Sharing: sharing of views and artefacts is possible on several levels: no sharing, sharing with one other member (e.g. sending it to your friend, or submitting it to a tutor), sharing with all your friends, sharing with groups, sharing with all members of the Mahara setup, sharing public (i.e. the web)

Groups: can be created by an admin, or autonomous by users (depends on the admin settings what is allowed). Groups can create own (group) pages, repositories, …

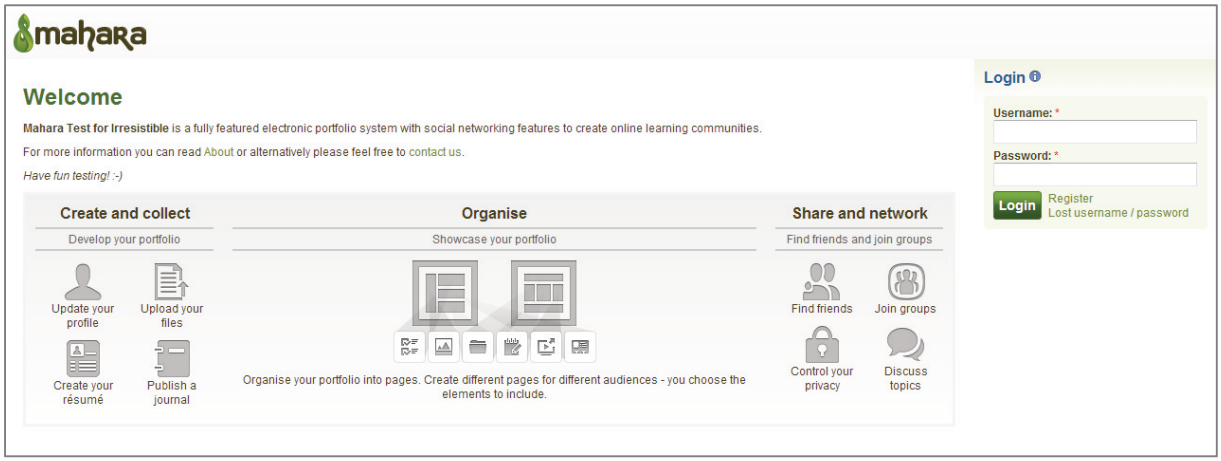
Forums: can be created by an admin, or autonomously by users, can have public discussion or only restricted to defined members (depends on the admin settings what is allowed).

# HowTo's

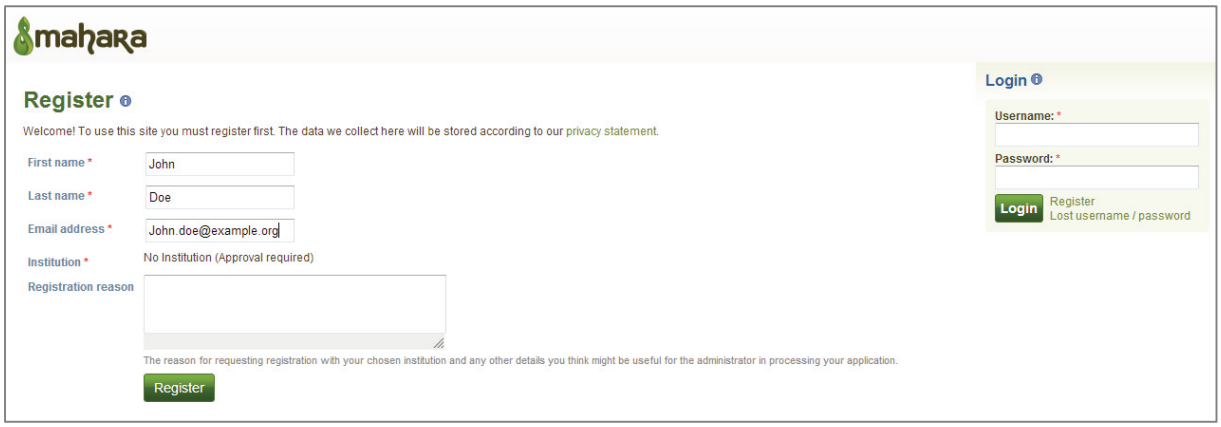
This should allow you to get started with Mahara in the workshop, and to probably explore it a little bit more in detail when you get back home… Mahara Version 1.8 is the base for this manual.

## HowTo: Set up an account

Go to the main page [www.kampschulte.org/mahara](www.kampschulte.org/mahara)

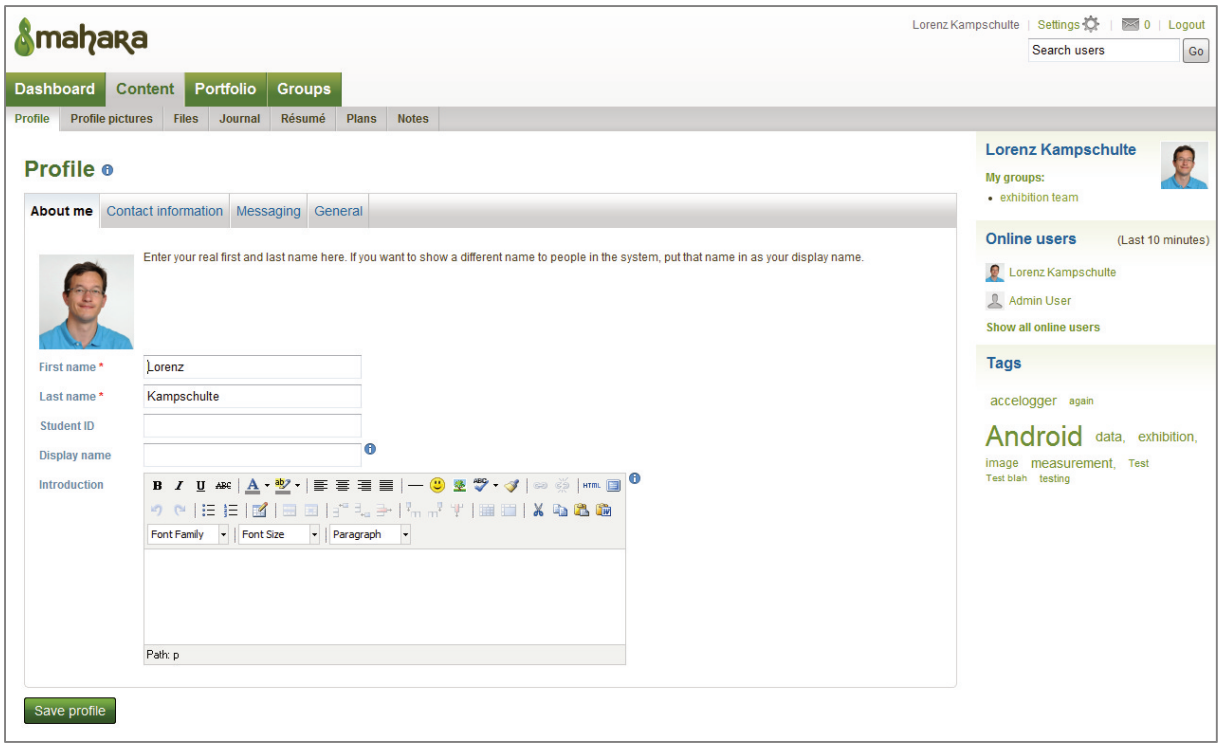



Click [Register]




Fill in your data, click [Register].


Then the admin will get an email, has to approve the request, then you'll get an email with a link to complete the signup process. Clicking this link will guide you to the a page asking you to create a user name and a password, and the set up your profile (e.g. profile picture, etc.)




## HowTo: General site elements

On the Mahara page you have several core elements:

[Dashboard] is you starting / home page, with links to all parts of your Mahara system

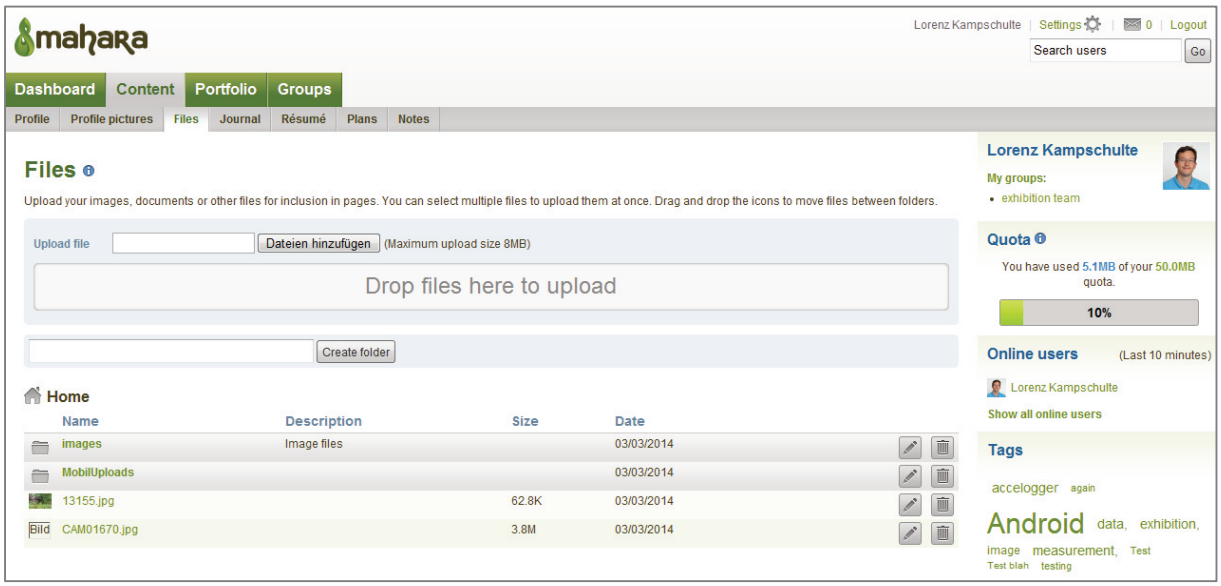
The [Content] tab holds all your personal data, e.g. profile, files, journal, resume, plans, notes, …

The [Portfolio] tab holds all pages and collections you created, and content you share with others. It also gives you export and import options for pages.

In the [Groups] tab you can manage all your contacts: find friends, become member of a group, dismiss membership, create own groups, …

## HowTo: Upload a file

Uploading files is really simple: Go to [Content] → [Files]

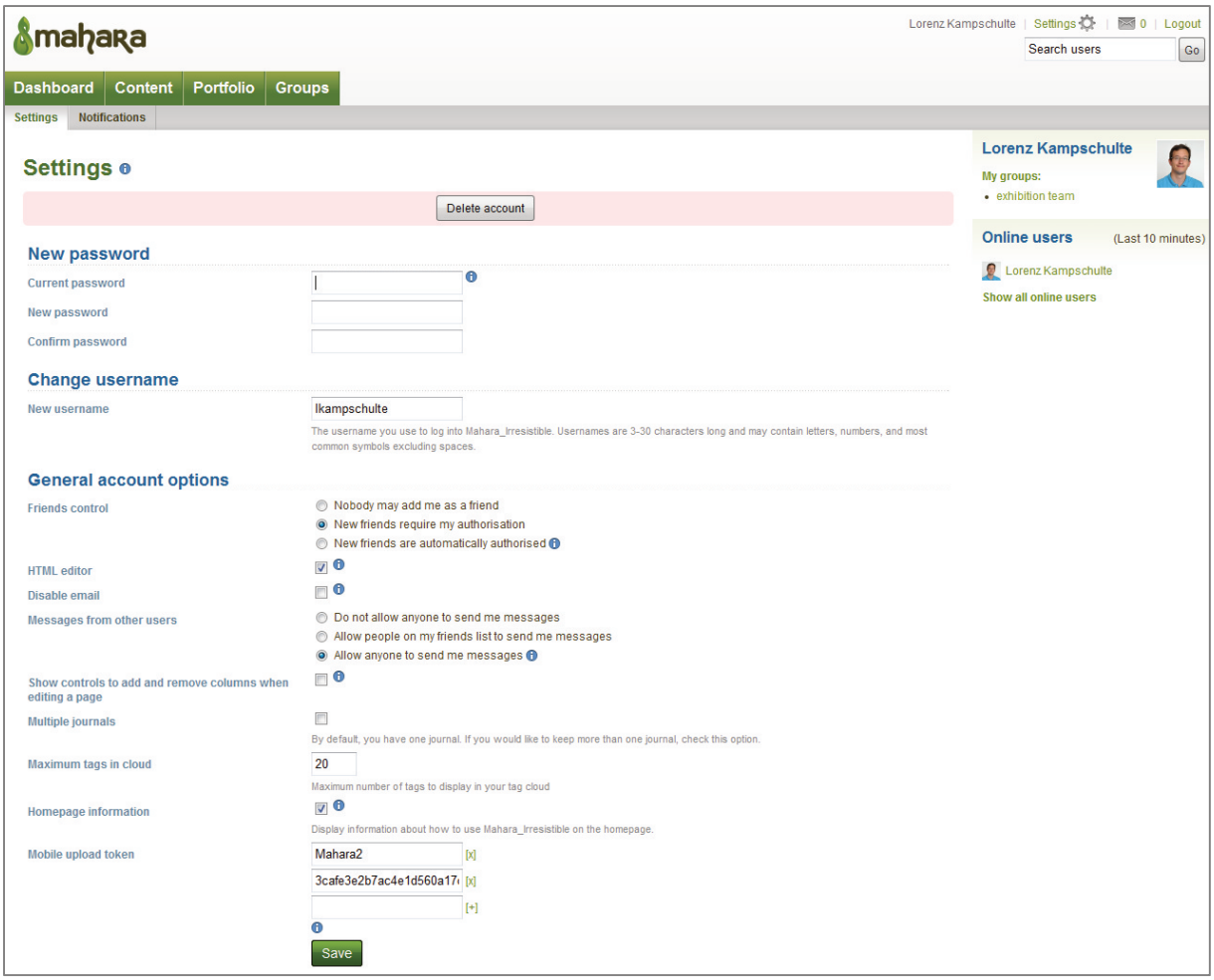



Just drag-and-drop the file on the [Drop files here to upload] field, or use the [Add file] button. In the lower part of the screen you have a list of all your files, can create folders and sort them. Hit the [Edit] button (pen symbol) to add a description and tags for your file.

## HowTo: Upload a file with a smartphone app

You can upload filed directly by opening Mahara in your mobile browser. But for Android OS as well as iOS there is an app making uploading even easier. A big advantage is that you can store files in the app, and can upload it later if you are back to a free WLAN connection (so save your data plan).

On your Mahara page go to [Settings] (upper right corner), and at the end of the page enter a [Mobile upload token]. This could be a very simple ID like “Mahara” or your name for the first connection, every time uploading artefacts the system will change the token and then use more secure codes (like the one shown here in 2nd line). Hit [Save].

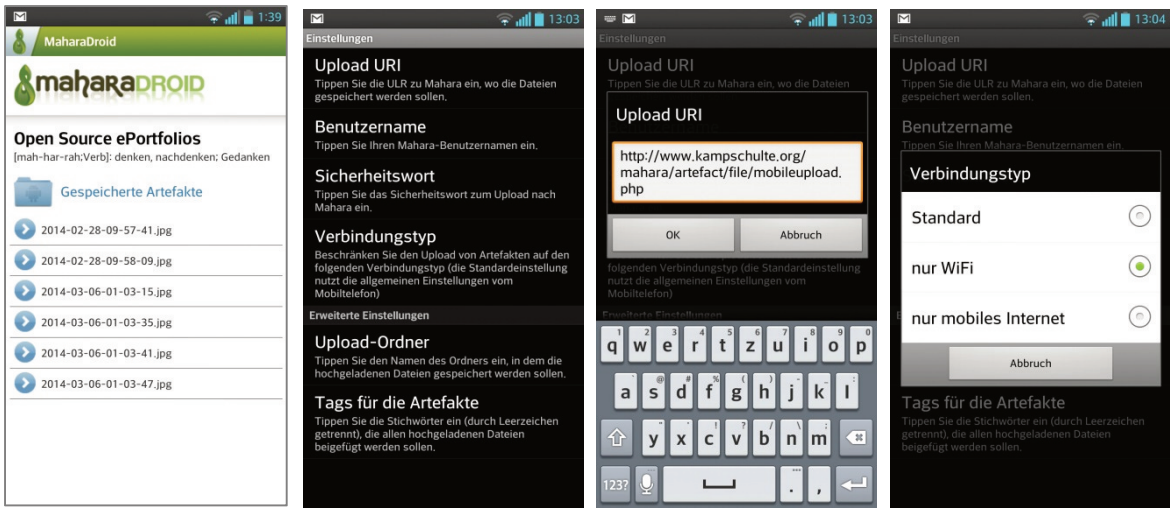



Install the app from the app shop on your phone: MaharaDroid (Android) or PortfolioUP! (iOS)

In the settings dialog of the app, enter the Upload URI as shown below (just change the first part to [http://www.kampschulte.org/mahara…]), enter your user name, and the token you just set on the webpage of Mahara (i.e. “Mahara”). You also can choose which connection type should be used, change to [WiFi only].

Ok, that’s all. Close the app.

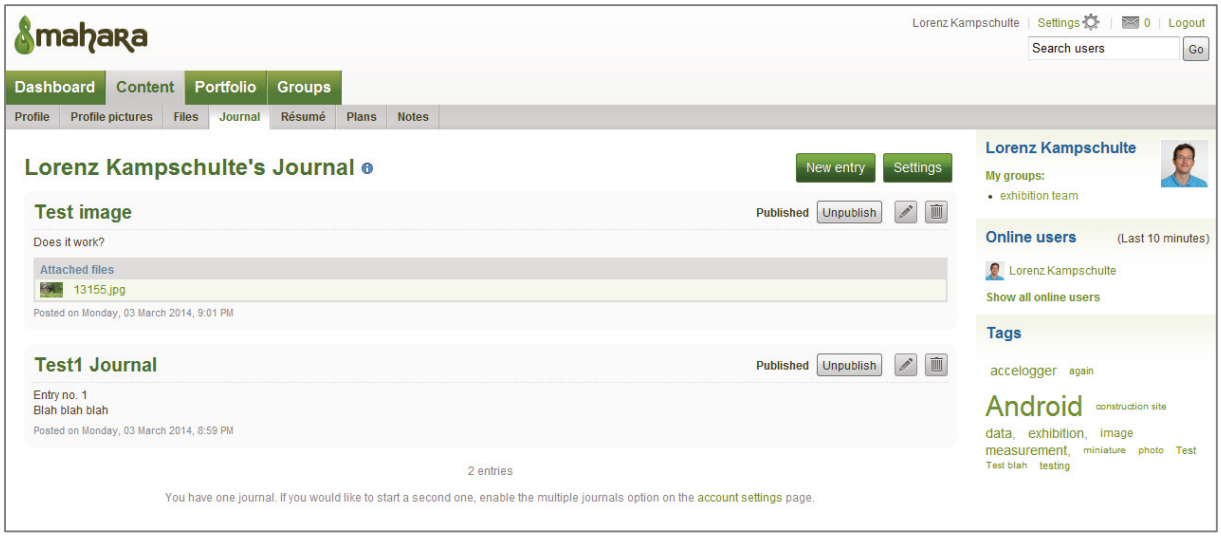
If you are now hitting any sharing button on your device (e.g. in photo gallery), you will have a button called [MaharaDroid] or similar for iOS. If you hit that button you get a dialog to change the file name, description, and to tag it. Then you can directly upload the file, or store it and upload it later, together with other files or when you have decent network.




All files are uploaded to your file repository, into the folder specified in the app, usually called “MobileUploads”.

## HowTo: Create a Journal

Go to [Content] → [Journal]. The first journal is already included in the basic settings, you can add further journals.



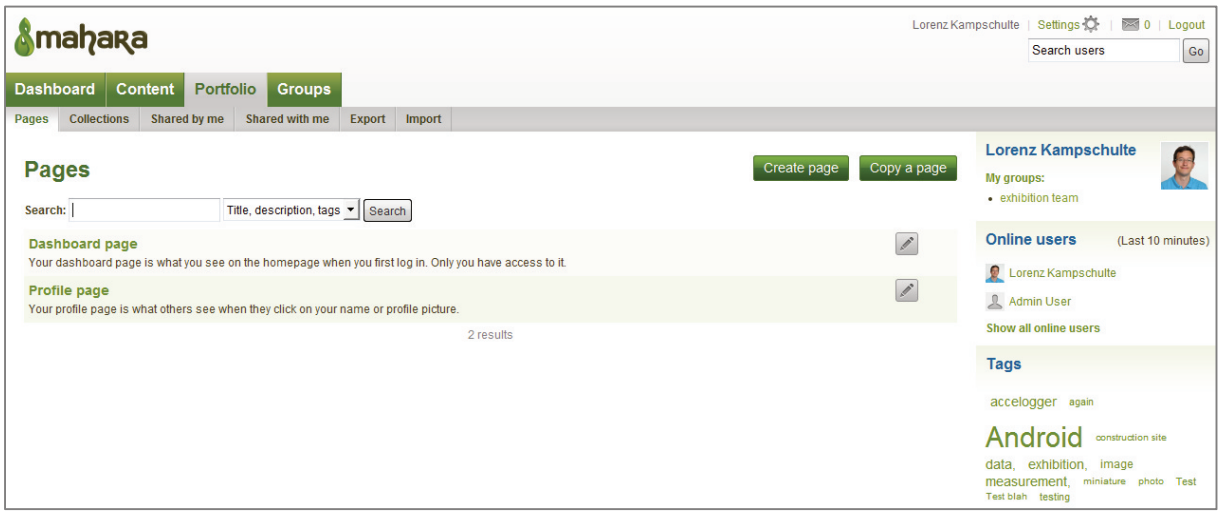

To create an entry, just hit the [New entry] button.

You can change the journal name and add a description as well as tags in the [Settings] menu (the button right next to the button [New entry].

A journal entry usually contains a title and the entry itself. You could add tags and files as you like.

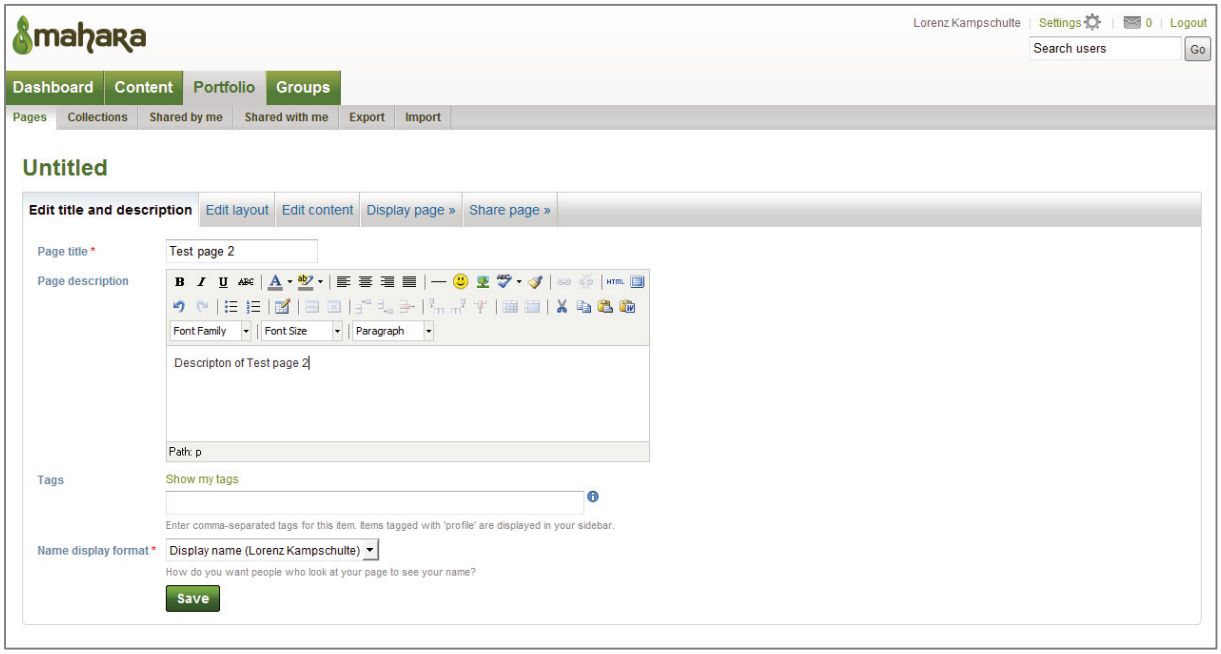
## HowTo: Create a Page

Go to [Portfolio] → [Pages]. You can create as many pages as you like.




To create a new page use the [Create page] button on the right. Dashboard and Profile page are installed on every profile. Dashboard page is your (customizable) start page when you log in, Profile page is the page you can design to introduce yourself to other Mahara users in your Setup.

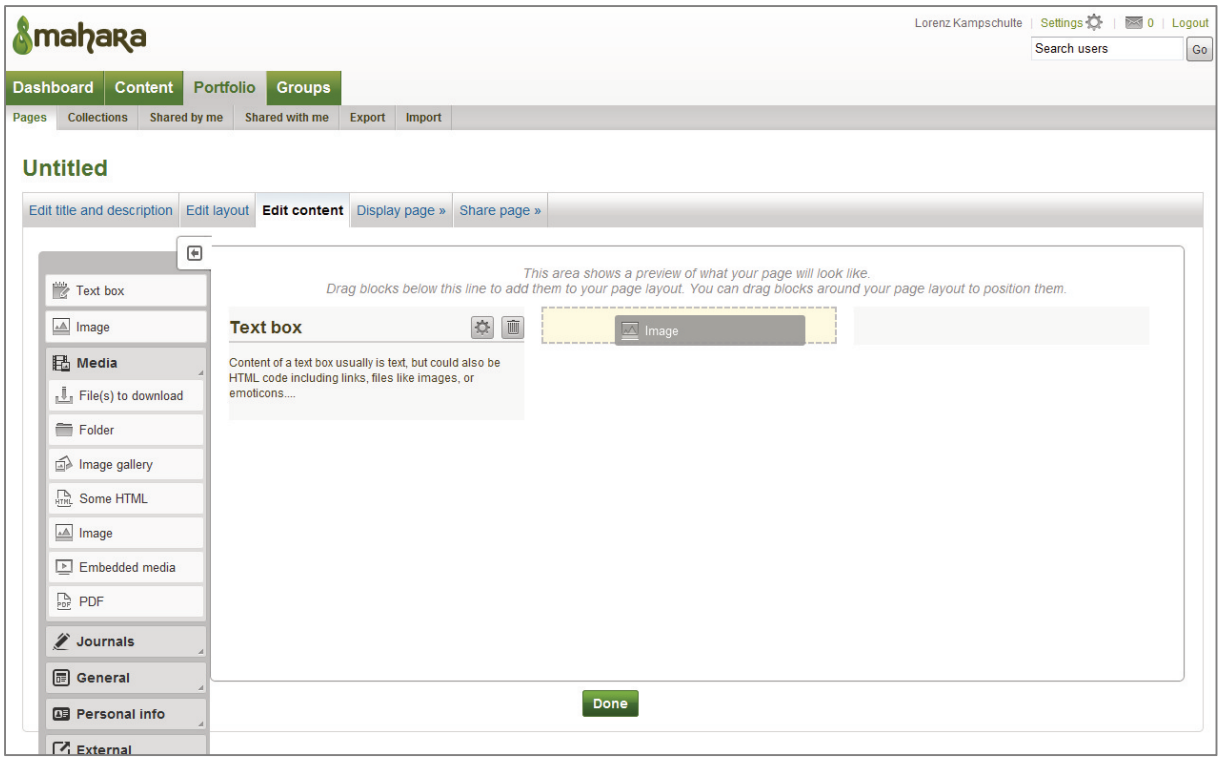
When you start with a page:




Set a page title and a short description of the page. Use the blue tabs for further settings.

Set the layout to the style you need (basically how many columns, rows, … you can change that later as well).

Add end edit content:




Just drag-and-drop the content placeholders from the menu on the left to your page on the right. If you have specified the position, an options menu opens where you can add and edit the content, e.g. set a title, text, image, video, pdf, … whatever you like. You can combine internal content (e.g. images, movie clips, …) uploaded to your Mahara repository, and external content like YouTube clips, which then will be embedded in your page. If you add a PDF box and specify a file to it, you'll see a simple PDF reader embedded in your page showing the document. Finish the dialog with the [Save] button, and it will be included in your page.

The tab [Display page] gives you a preview of your page.

At the tab [Share page] you can set who can see your page. Besides others, you can allow users to only view your page, or to copy it and work on it. So as a teacher, you can create framework pages, share them with your students who fill in the content, and then share them back to you for review.

For all sharing, you can set a start and end date to define the time when it is accessible. When you share the page with the public, it might be wise to create a SecretURL. A standard Mahara page URL is something like http://kampschulte.org/mahara/view/view.php?id=17, a Secret URL would be http://kampschulte.org/mahara/view/view.php?t=KWRv0QElLYVXcIdTpFAG thus masking the page ID.

You can export your page in HTML code, so it is usable standalone without Mahara.

*Collection:*

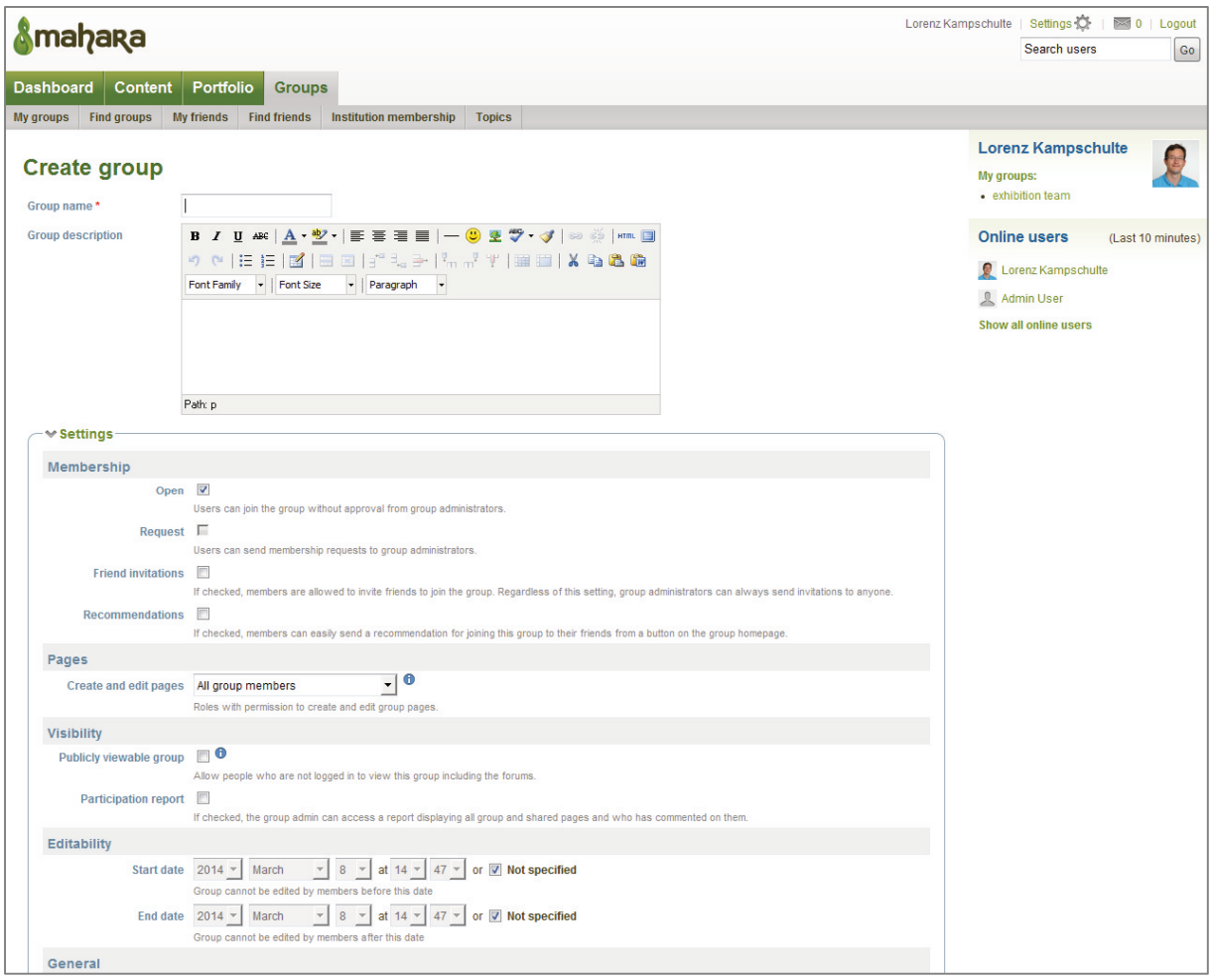
A collection is a set of pages that are linked to one another and have the same access permissions. You can create as many collections as you like, but a page cannot appear in more than one collection.

## HowTo: Create a Group

You have two ways to become a member of a group: Either search for groups and join them (could be free access or needed to ask permission to join from the group administrator), or found a group yourself.

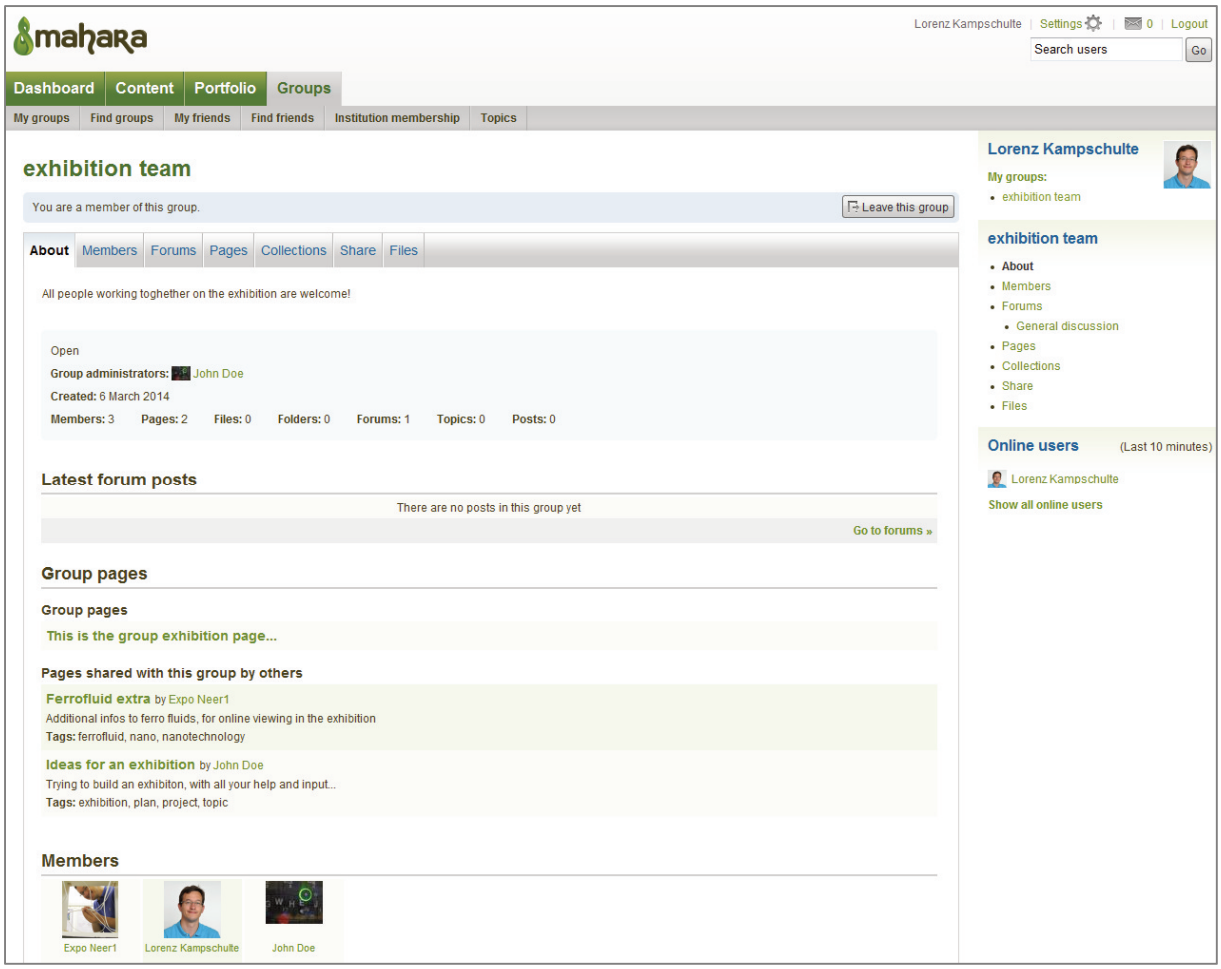
Go to [Groups] → [My Groups] → [Create a new group]


In the dialog for creating a new group you can specify the member permissions, e.g. how to enter the group, who is allowed to edit the group pages, …




Hit the [Save group] button at the lower end of the page.

Each group has its own set of pages, showing members, statistics, and giving access to group pages, collections, and a shared file repository (each group has their own quota share).




## HowTo: Create a Collaborative Page

If you want to create a page for the group where all members can contribute to, go on the before mentioned group home page (see screenshot above) to the tab [Pages], and then hit the button [Create page].

The procedure of filling the page with content is that same as for your private pages. Different users can work on the page and edit the content at the same time (but be aware that minor inconsistencies could happen, although the modular system of these pages helps keeping them low. I couldn't really generate inconsistencies, but with my three test identities I'm not really "multiple users"… Use your refresh button every now and then…).

# Sample Users

Here's a set of sample users I created for testing purposes. You can use them during the workshop, but I'll delete them in a few days due to security reasons… But setting up your own user account is really simple (see first paragraph of the HowTo).

Sample User 1:

User: John Doe
Username (login): johndoe
Password: abcdef

Sample User 2:

User: Expo Neer1
Username: Exponeer1
Password: abcdef

* END OF DOCUMENT *

# Examples of using ICT in a learning unit

## Additional ideas of how the tools could be integrated in the IBSE modules

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November 2015

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IRRESISTIBLE is a project on teacher training, combining formal and informal learning focused on Responsible Research and Innovation.
This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no 612367.

# Content

# Introduction

In addition to the Web2.0 / App Guide that is available on the IRRISISTIBLE website[1] and to the workshop held in Kiel in March 2014, this document contains several examples of how ICT tools could be integrated into the teaching units developed within the IRRESISTBLE project.

Whereas the Web2.0 / App Guide's aim is to present the large variety of tools available on the marked and to spark ideas of what could be used in general, the goal of this document is to give examples of how some of the tools could be integrated in a module. It presents three fictive illustrations on different topic areas: using an e-learning platform for collecting basic knowledge on plastics, employing different apps to optimize solar power, and a unit on calculating and comparing $CO_2$ footprints for food and travel. The examples have an illustrative character and are focused on including ICT tools rather than giving full content teaching units.

To support the integration of ICT in the teaching modules developed within the IRRESISTIBLE project, the examples illustrate the core topics of the project, namely Responsible Research and Innovation (RRI), Inquiry Based Science Education (IBSE), gender issues and exhibitions. Table 1 gives a brief overview on the main aspects represented in the different examples.

In addition to these examples shown in this document, another use case on working with different app tools and integrating the results on the e-learning platform Mahara is documented in the Deliverable to the workshop, D4.2[2].

Further reading: Science on Stage Deutschland e.V. recently published a comprehensive collection of ICT tools and examples. These can be found in the booklet "iStage 2 – Smartphones in Science Teaching" that is available on their website[3] (pdf version and print copy to order, both free of charge).

[1] http://www.irresistible-project.eu/index.php/en/resources
[2] http://www.irresistible-project.eu/index.php/en/resources/deliverables
[3] http://www.science-on-stage.de/page/display/en/7/7/0/unterrichtsmaterialien//

Table 1: Indicating the core topics of the IRRESISTIBLE project being present in the following examples.

| Unit | Responsible Research and Innovation (RRI) | Inquiry Based Science Education (IBSE) | gender issues | exhibitions |
|---|---|---|---|---|
| **Unit on Plastics: Introduction to Plastics using Mahara** | Discussion on environmental issues of plastic, sustainability, bio-friendly alternatives, … | - | - | Presentation of the results gathered in the unit on the school website |
| **Unit on Solar Energy: Defining the Best Position for a Solar Cell using different ICT Tools** | - | Student groups are working on research tasks to find the best conditions for obtaining solar energy | - | - |
| **Unit on $CO_2$ Footprints: Calculating and Comparing $CO_2$ Footprints for Food and Travel** | The topic of $CO_2$ footprints instantly offers many starting points for RRI, e.g.: Knowing how they are calculate ('Science Education'), Regulations on $CO_2$ emissions ('Governance'), contributors to the problem ('Engagement'), … | Tracking individuals $CO_2$ footprint travelling to school for one week, comparing and discussing results | Comparison and discussion of the CO2e footprint of female/male eating behavior (group work2) | Presentation of core results as a poster |

# Unit on Plastics:
## Introduction to Plastics using Mahara

This example illustrates a teaching sequence on plastics. It starts with a reference to plastic as part of our daily environment and then introduces the basics about the production and use of plastic materials. Towards the end, it raises questions about substituting plastics and other ways to reduce the immense problems it creates today. During the whole unit, students work and document their results on the e-learning platform Mahara. At the end, the results collected during the teaching unit are presented on the school website. Mahara is just an example tool to be used here, there are comparable tools around that could be used in a similar way (e.g. Edmondo[4]).

## Activity sequence

### *1. Introduction to Mahara*

Introduction of the students into the e-learning system Mahara, creating user accounts for the learners. (A brief introduction to the e-learning platform Mahara in included in the IRRESISTIBLE Web2.0 / App Guide[1], pp. 23-33.)

### *2. Entry task: everyday reference*

The students get the task, to photograph at home three different objects made of plastic. The objects should be as different as possible. Afterwards these images should be uploaded to the *content* section of their individual Mahara account (in Mahara jargon they are then called *artifacts*). This can be either done by using their own smartphone and the Mahara app, or done in a classical way by using a digital camera and upload the images via the browser interface.

In the following lesson, a joint Mahara *group* for the project is established and the images are collected in a common *portfolio*. The pupils are asked to find categories themselves by which to sort the plastic pictures (this could be e.g. color, hard/soft, use cases, …). If several classifications occur, multiple portfolios can be created and filled. In the following, the different sorting criteria are discussed by the learners, either face-to-face in class or digital within a Mahara *forum*.

### *3. Topic plastics*

In the following lesson(s) the students are introduced to the topic of plastic. The introduction unit to plastics could incorporate e.g. structure, fabrication (polyreactions), properties, labelling ... From this knowledge, new criteria arise to sort the plastic in different categories.

[4] https://www.edmodo.com/

When the new categories are developed, a new Mahara *portfolio* is created. As introduction to each category the nature, structure and main properties are briefly described. The students try to find out which plastic the photographed objects are made of and sort the images into the new categories.

### *4. Topic recycling*

Short teaching unit on plastic: “Problems with Production and Recycling”. Assessment of different plastics with respect to their sustainability (considered over the entire life span). Adding the results to the new plastic *portfolio*.

Subsequently, the task to research bio friendly alternatives to the plastics shown in the portfolio is assigned to the students. The alternatives should have similar characteristics and thus should be able to serve as a direct substitute for the original plastics. If appropriate, other groups with secondary tasks are formed, for example, how recycling can be further improved or how the construction of products can be optimized to reduce the use of plastic and to ease recycling (reduced quantity of conventional plastic, composite materials, recycling friendly construction ...). The research results of the groups are collected on further Mahara *portfolios*, the (digital) discussion can be handled within topic-related Mahara *forums*.

### *5. Presentation*

Each group prepares a final *portfolio* page or a small series of *blog* entries within Mahara, which summarizes the main findings of their group work in a multimedia format. These contents are first presented to the class, then released as a public Mahara *portfolio* and embedded in the school website.

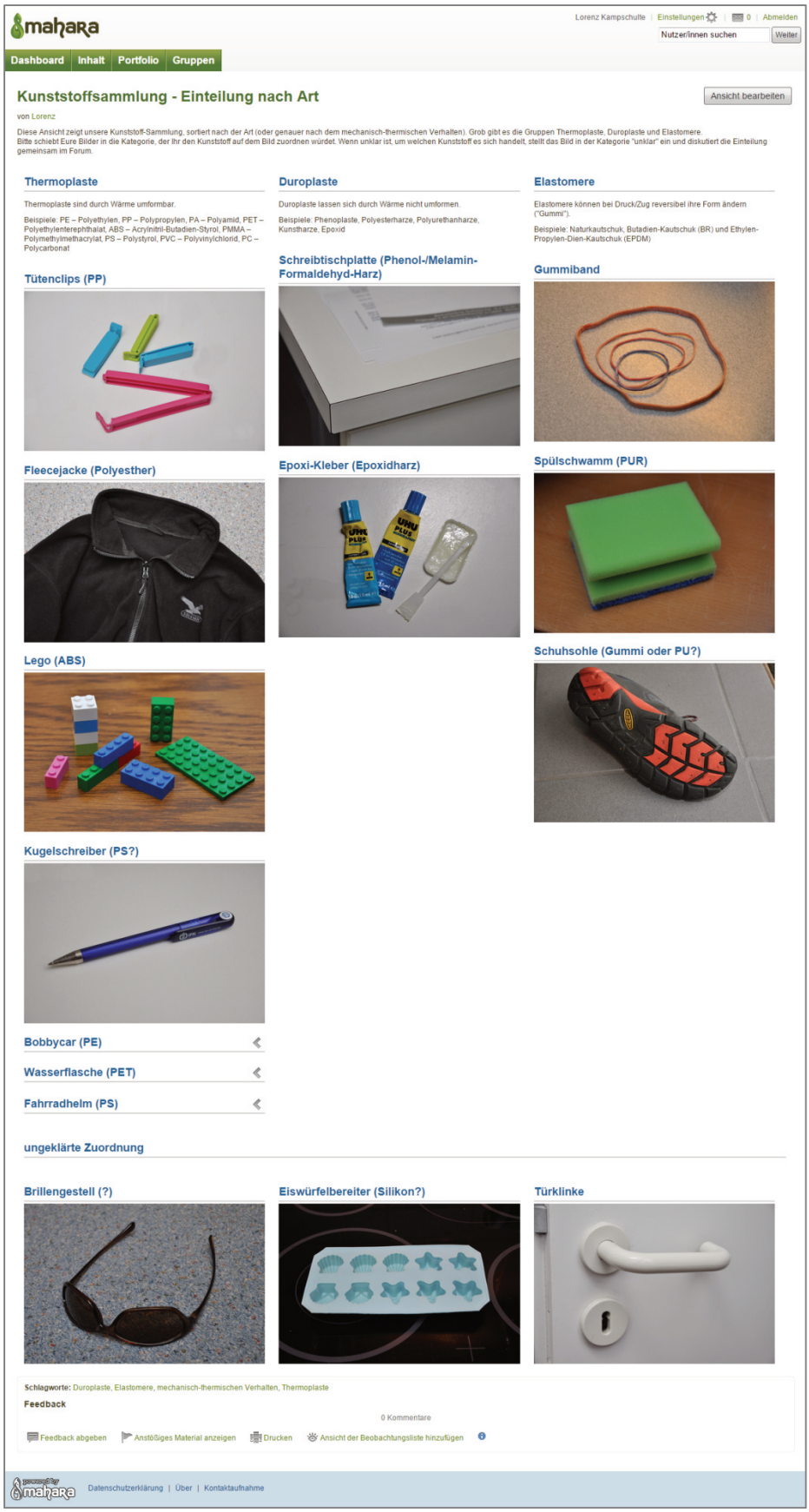


**Figure 1: Example of a Mahara *portfolio* during the sorting process: The photographs of the students are grouped in four categories: thermoplast, duroplast, elastomer, unsettled.**

# Unit on Solar Energy:
## Defining the Best Position for a Solar Cell using different ICT Tools

In this example, a teaching unit on solar energy is presented, especially looking on the influence of the solar panel position on the highest possible power generation. The class is divided in three groups looking at different aspects: the local position (e.g. influenced by houses, trees …), the regional position (e.g. influenced by topography, sunshine duration …), as well as the technical position (e.g. orientation, tilting angle …). During the units, the groups work with different ICT tools to fulfill their tasks, the tools are either smartphone or computer based. The tools are just examples that could be used, several other tools are available that could be used in a similar way.

## Activity sequence

### *1. Introduction*

Solar energy is a fundamental part of all scenarios to ensure the global energy supply in the future. Until the vision of a 'solar paint', that can be applied to almost all surfaces turning them into effective peripheral power generators comes true, we have quite a way to go. Today's state of the art technology is photovoltaic solar panels being based on polysilicon or thin films. These have two main drawbacks: they still are moderately expensive (so it's not possible to 'just cover' all available surfaces), and their efficiency is highly dependent on the orientation towards the light incidence. The latter effect should be investigated within this unit.

### *2. Group 1 – school yard*

Task: Find the best spot to place a 2 m² photovoltaic solar panel on your school yard. Take factors as sun position during day, seasonal sun position, obstacles (houses, trees) into account. Use the App Sun Position[5] or Sun Surveyor[6] to work out the best place.

As a result, take (or draw) a map of you school yard and indicate your 1st and 2nd choice position. Draw a table and list the relevant factors for both positions.

[5] https://play.google.com/store/apps/details?id=com.andymstone.sunpositiondemo&hl=de
[6] https://play.google.com/store/apps/details?id=com.ratana.sunsurveyor&hl=de

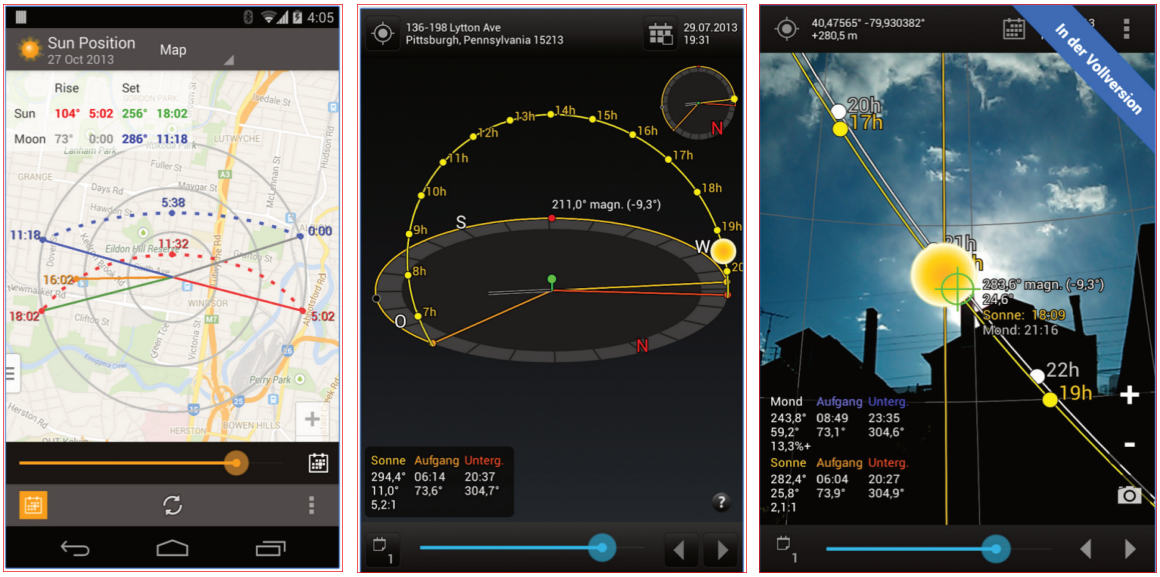


**Figure 2: Screenshots of the apps Sun Position (left) and Sun Surveyor (middle and right) to determine the best position for a solar panel (screenshots: [5],[6]).**

### *3. Group 2 – regional position*

Task: Find the best spot for a small communal solar power plant (200 m² base area, photovoltaic) within a radius of 50km from your school location. Take factors as local sunshine duration, topography, sites (buildings, grassland, large roofs …) into account. Use Tools like Google Earth[7] (topography, site options), sunshine duration maps[8], or tools to analyze the course of the sun for a specific place[9] …

As a result, take a map of the area under investigation and indicate your 1st and 2nd choice position. Draw a table and list the relevant factors for both positions.

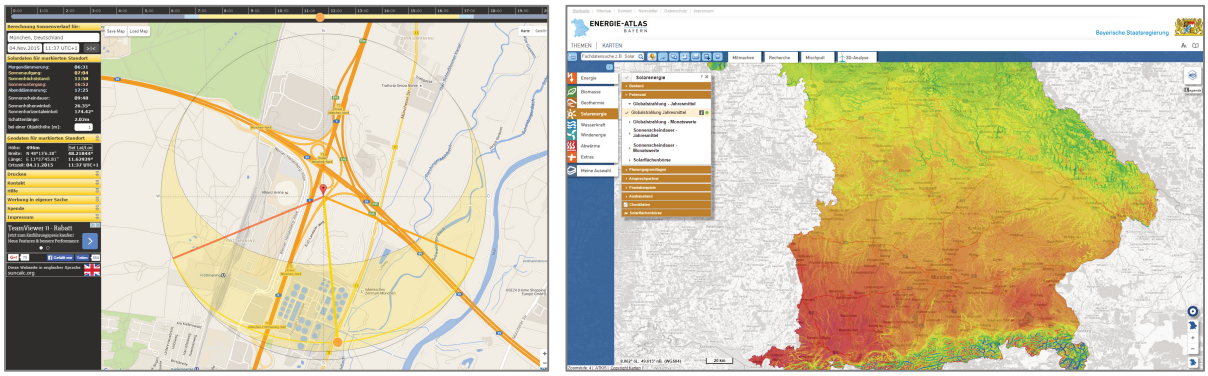


**Figure 3: Course of the sun simulated on sonnenverlauf.de[9], map of global radiation for southern Bavaria[8].**

[7] https://earth.google.com/
[8] http://geoportal.bayern.de/energieatlas-karten (similar maps should exist for most regions)
[9] http://www.sonnenverlauf.de/#/48.2184,11.6294,15/2015.11.04/07:24/1

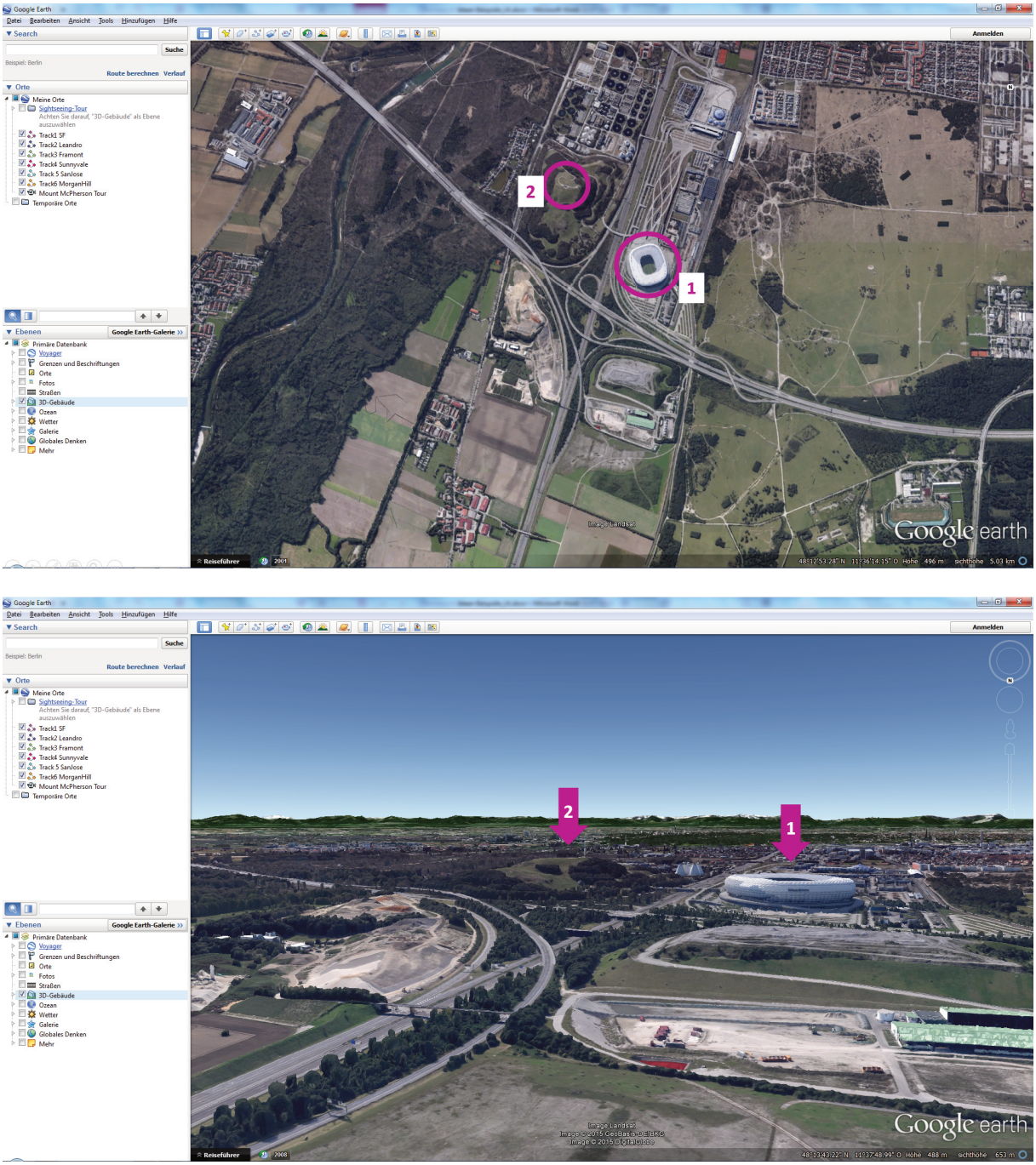


**Figure 4: Two possible positons for a small PV solar power plant, visualized in Google Earth[7]: (1) on the roof of a football stadium, (2) on the top of a small hill close by.**

### *4. Group 3 – optimal position to the sun*

Photovoltaic solar cells are most effective, when the sun hits perpendicular onto the solar panel. Tilting to panel +/- 20° off the optimal position results in ~17% power loss, when tilting it to +/- 50° only 10% of the maximum power is left.

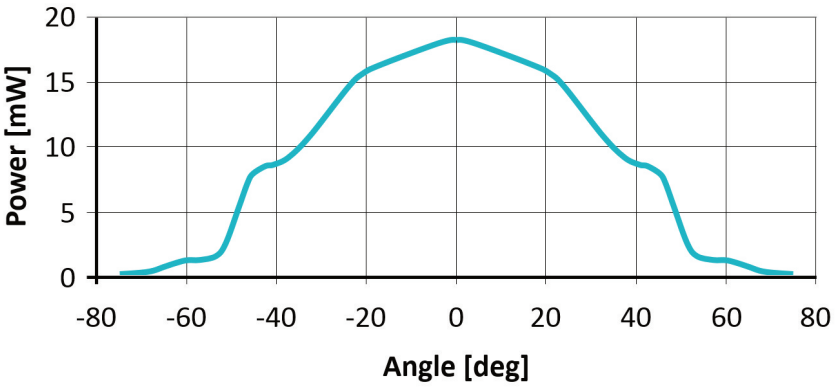


Figure 5: Angle dependent power of a typical solar cell.[10]

Task: Find out the optimal orientation of a solar panel towards the sun under the current situation. Search for a sunny spot on your school yard. Draw a compass rose with the four cardinal points on a sheet of paper. Use a smartphone to determine the north direction, align your compass rose and tape it to the ground. Now use the App Light Meter[11] (or a similar one) and systematically try to find the orientation with the highest light intensity, alternating optimizing East-West orientation and tilting angle. When the optimum point is reached, note down the maximum light intensity (in Lux), the East-West orientation and the tilting angle in a small table. You can either use a set square and a compass, or smartphone apps like Smart Level[12] and Smart Compass[13]. Since these values are highly dependent on the current situation, note down exact location (GPS), date and time as well.

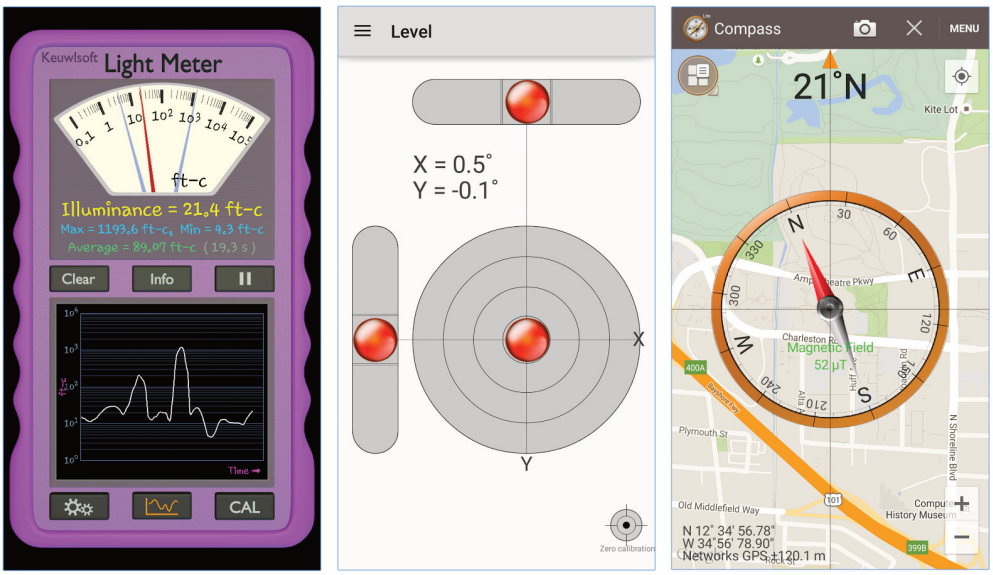


Figure 6: Screenshots of the apps Light Meter, Smart Level, Smart Compass (screenshots: [11],[12],[13]).

[10] source of data: http://www.drollinger-wds.de/benjamin/study/docs/et_solar.pdf
[11] https://play.google.com/store/apps/details?id=com.keuwl.lightmeter&hl=en
[12] https://play.google.com/store/apps/details?id=kr.sira.level&hl=de
[13] https://play.google.com/store/apps/details?id=kr.sira.compass&hl=de

Now tilt the smartphone 20° off the optimal position. Roughly, how much is the “power” (aka light intensity) reduced as compared to the maximum “power”? (You most probably will measure a different decrease than mentioned in the example above, since your smartphone sensor is not a real solar cell, and the angle is also dependent on how the sensor is mounted in the smartphone – nevertheless a significant decrease should be measurable.)

### *5. Summary*

Each of the three groups presents their findings in a brief PowerPoint presentation. Discuss how you can optimize your solar power plant including all findings (especially group 2 and 3). From the results of group 3 it can be concluded that following the sun with the solar panel would be a good option to increase the overall power output. But that is done very seldom – why?

# Unit on $CO_2$ Footprints:

## Calculating and Comparing $CO_2$ Footprints for Food and Travel

This example illustrates a teaching unit on carbon footprints. Carbon footprints are "a measure of the total amount of carbon dioxide ($CO_2$) and methane ($CH_4$) emissions of a defined population, system or activity, considering all relevant sources, sinks and storage within the spatial and temporal boundary of the population, system or activity of interest. Calculated as carbon dioxide equivalent ($CO_2e$) using the relevant 100-year global warming potential (GWP100)."[14] Working with and reflecting these measures, students should get an idea on the dimension of $CO_2$ emissions and how the individual can influence climate change by controlling their own behavior. In the teaching unit, several apps and websites are used to explore, compare and track the individual carbon footprint.

The teaching module on Climate Change developed by Finland within the IRRESISTIBLE project includes several aspects on $CO_2$ and Carbon footprints[15].

## Activity sequence

### *1. Introduction*

Starting the introduction with a more general approach to climate change and the role of CO2 and other greenhouse gases. Basic introduction to the concept of carbon footprints, illustrating their role in terms of direct emission (e.g. transportation) and indirect emission (e.g. food, textiles …) with the latter having a special look on lifecycle analysis.

### *2. Determining the $CO_2$ emission of getting to school for one week*

Introduce students to using the app Changers CO2 Fit[16]. The app allows to track all travelling, calculates the CO2 saved, and rewards the user with green bonus points called ReCoins.

Let the students track their way to school (or all travelling) for one week, collect, compare and discuss the results.

[14] Wright, L.; Kemp, S.; Williams, I. (2011). "'Carbon footprinting': towards a universally accepted definition". Carbon Management 2 (1): 61–72. doi:10.4155/CMT.10.39.
[15] http://www.irresistible-project.eu/index.php/en/topics
[16] https://play.google.com/store/apps/details?id=com.blacksquared.changers&hl=de

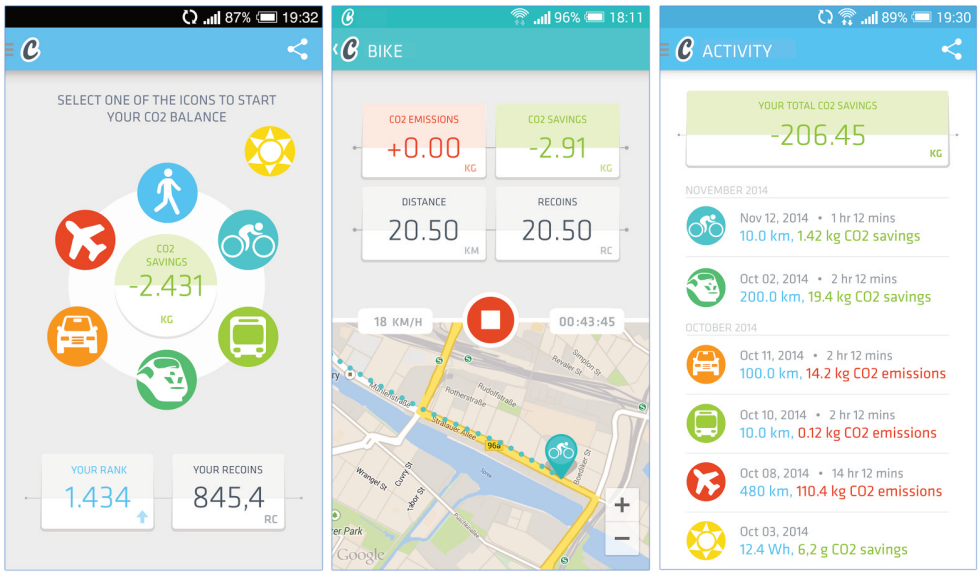


**Figure 7: Screenshots of the app Changers CO2 Fit: start screen, travel screen, list of travel activities (screenshots [16]).**

### 3. *$CO_2$ emission caused by food*

Calculating the $CO_2$ footprint of food is quite complicated, since many factors influence the footprint: production conditions, production itself, wrapping, transport, storage, retail system, transport to household … Discuss these factors and their potential share in the total footprint of the food product. Also take the contribution of other greenhouse gases into account (e.g. Methane ($CH_4$) when producing meat), which are far more dangerous than $CO_2$. Introduce the Global-warming potential (GWP) of greenhouse gases and the concept of carbon dioxide equivalents ($CO_2e$)

Group work1: Students explore the different food and respective carbon dioxide equivalents ($CO_2e$) on the webpage Eat Low Carbon[17]. Let them write down three food ingredients that they presume to have a very low $CO_2$ emission, and three food ingredients that have a very high emission. Discuss the findings.

Group work2: The class is separated in female-only and male-only groups. Each group gets the task to choose the food for each person and day, based on the meals they like best. Then students calculate an average $CO_2e$ footprint for the daily food ration within their group. Compare the results between the groups. Is there a difference between female and male groups? Discuss the results in terms of worldwide eating behavior and world population.

[17] http://www.eatlowcarbon.org/food-scores/

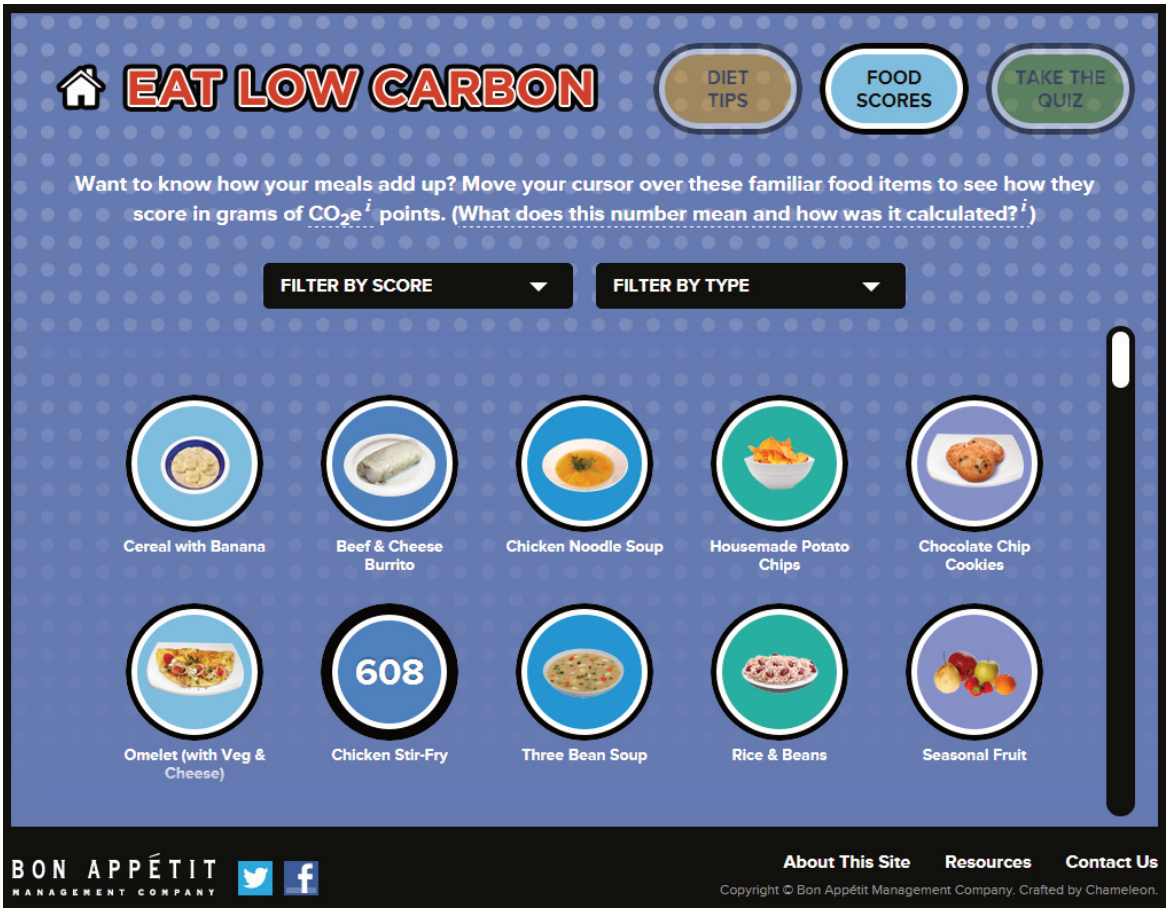


**Figure 8: Screenshot of the website Eat Low Carbon. The page contains a huge variety of food and meals, hovering over the photo with the mouse indicates the grams of $CO_2e$ (screenshot [17]).**

Note: some nice examples of professional $CO_2e$ calculation are listed on the website of CleanMetrics[18] (right column).

Note for an extended project: With the app Veggietizer[19] one can easily calculate how much $CO_2$, water and crops can be saved by banning meat from your meal.

### *4. Summary*

Discuss the findings on CO2 emissions from food and travel. For consolidating the results of the unit, let the students make a joint poster which could have three parts:

- Introduction, explaining CO2 problem and concept of carbon footprints and carbon dioxide equivalents ($CO_2e$)
- Catching examples to present: compare travelling a specified distance by plane, by train, by bus, by car and by bicycle and/or compare meat: beef from Argentina, local beef, local poultry

[18] http://cleanmetrics.com/html/foodcarbonscope.htm
[19] https://play.google.com/store/apps/details?id=freerunningapps.veggietizer&hl=en (currently only a German version available)

- Students research the $CO_2e$ for ten different kinds of food (e.g. 100g of pasta, 100g soy milk, 100g beef, …) and calculate how far you could travel with a car producing the same $CO_2$ emission (for a graphic inspiration look at the illustration of the $CO_2e$ of different products published by the meateatersguide[20]).

Hang up the poster in a frequented spot in the school building to spark discussion between students.

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[20] http://static.ewg.org/reports/2011/meateaters/images/eatsmart_twenty.gif