University of Cologne

Faculty of Management, Economics and Social Sciences

Cologne Institute for Information Systems (CIIS)

Sustainable Digital Innovation Lab

Course Instructors

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Goals of the Module

Students...

... understand the meaning of digital innovation and learn important related concepts.

... learn about the potential of emerging digital technologies.

... understand the challenges of designing information systems for digital innovation.

... develop an idea for a digital innovation using the latest digital technologies.

... develop a socio-technical artifact based on their idea.

... organize themselves and work in independent teams.

... independently manage time, team and project conflicts.

... communicate processes and results to relevant stakeholders.

Content

This course is structured as a project-based digital innovation lab. The aim is to develop a novel digital solution to address a sustainability challenge. With this goal in mind, we have two specific areas of focus.

1. Address a Sustainability Challenge

We define a sustainability challenge as a problem with either environmental or social value, but not primarily commercial value (George et al. 2020; Qureshi et al. 2021). We draw inspiration from the *United Nations Sustainable Development Goals*, which provide a set of targets and an agenda for peace and prosperity. Another source of inspiration for environmental sustainability in

innovation challenges is the *Fridays for Future* movement, which grew out of school walkouts demanding action to prevent further global warming.

Concrete project examples include the *Fairphone* - a highly modular smartphone that takes into account conflict-free production resources, worker welfare and e-waste programs - or *Wakawaka* - a solar-powered lamp that provides 16 hours of reading light with less than one day of sunlight. It is important to note that not all innovations can be classified as sustainability innovations. For example, we do not consider lean manufacturing to be a sustainability innovation, as it is primarily aimed at increasing the efficiency of production processes and may only reduce waste as a side effect. Other negative examples are greenwashed products and practices that make unsubstantiated or even misleading claims about their environmental benefits (e.g. reducing carbon footprints). This course aims to broaden students' understanding of the major sustainability challenges facing current and future generations and the potential of digital technologies to address these challenges.

2. Develop a Digital Artifact as a Solution to the Innovation Challenge

The digital solution must consist of both hardware and software components. For the hardware components, we will provide a selected hardware technology stack for students to work with. Students' task is then to develop a software solution for the hardware technology stack so that a digital innovation can be realized. Consider these examples for illustration:

- Vertical Hydroponic Farm Arduino Project (Langdon 2015)
- Self-powered water meter for direct feedback regarding safe water consumption (Tasic et al. 2012)
- Meter devices for smart and energy-efficient school buildings (Pocero et al. 2017)
- Open source low-cost power monitoring system (Oberloier and Pearce 2018)
- Wireless sensor network system for environmental monitoring applications (Ferdoush and Li 2014)
- A datalogger for irrigation water use monitoring to enable crop management (Spinelli and Gottesman 2019)

With these foci, the contents of the unit roughly unfold in the following way:

- Digital innovation and grand challenges of a sustainable society
- Selected emergent digital technology stacks
- Systems development practices suitable for complex contexts and requirements
- Project and team management
- Design, development, and implementation of digital technology
- Prototyping and Testing

Procedure

Students will work in teams to complete this unit. In teams, they will be free to choose the problems they want to address in their digital innovation project. A selection of hardware technologies will be available at the beginning of the course to allow students to begin experimenting immediately. Team formation is scheduled for the kick-off session. Prior to this, students are encouraged to familiarize themselves with some preparatory material and to complete a short survey that can be used for team formation. During the semester, students will be able to use a fixed budget to purchase additional hardware components such as sensors, extensions, motors, tools, etc. for their projects as needed. Orders must be placed through the course instructors.

Student teams will work continuously and independently on their digital innovation solution throughout the semester. The course will include a series of accompanying lectures, tutorials, and interactive workshops. For the workshops, students will be provided with resources and materials in advance to prepare for the workshop in a flipped classroom style.

The final report and solution should be submitted using a free and open source design solution that meets the requirements of a professional publication such as HardwareX - an open access journal established to promote the free and open source design, construction, and customization of scientific infrastructure (hardware). Therefore, reports must provide potential end users with sufficient information to replicate and validate the advances presented. More information on documentation requirements and examples can be found on the journal's website. The General Public License (GNU) is recommended as a compatible open source licensing model.

Technology Stack

We provide students with hardware technologies that can be used for experimentation and testing right out of the box. The following list is intended as a starting point rather than a comprehensive list of technologies that can be used.

- Arduino Hardware Platform – the central part is an open-source microcontroller board, including an integrated development environment
    - Official Site: https://www.arduino.cc/
    - Arduino Project Hub: https://create.arduino.cc/projecthub
- Circuit.io – a prototyping tool for instant circuit schematics and code for electronic circuit
    - Official Website: https://www.circuito.io
    - Blog: https://www.circuito.io/blog
- GitHub – a software platform for version control, collaboration, and source code management; one of the largest hosts of public source code:
    - Official Website: https://github.com/
    - GitHub Guides: https://guides.github.com/

For more inspiration on technologies and tools to use, students should take a look at *Stackshare.io,* which provides lists of technology stacks and tools.

Location

For lectures, workshops, team and lab work, we have booked a seminar room and a digital lab throughout the semester located in the WiSo-Modulbau (Universitätsstr. 24). For workshops and lectures, please refer to the schedule in KLIPS2 and ILIAS.

Schedule

Week	Date	Time	Topic
1	Di, 14.10.2025	08:00-13:30	**Kick-off Workshop**
1	Mi, 15.10.2025	08:00-11:30	**Initiation Workshop**
2	Di, 21.10.2025	08:00-11:30	**Ideation Workshop**
3	Di, 28.10.2025	08:00-11:30	**Lecture and Workshop - Conducting User Research**
4	Di, 04.11.2025	10:00-11:30	**Presentation of Problem Definitions (Assessment 1)**
5	Di, 11.11.2025	-	*NO CLASS (Carnival)*
7	Di, 18.11.2025	08:00-11:30	**Lecture and Workshop - Design Approaches for Digital Innovations**
8	Di, 25.11.2025	-	Independent Work on Solution Concepts
9	Do, 02.12.2025	-	Independent Work on Solution Concepts
10	Di., 09.12.2025	08:00-11:30	**Presentation of Solution Concepts (Assessment 2)**
11	Di., 16.12.2025	10:00-11:30	**Introduction to Lab Tools (e.g. 3-D Printer)**
12	Di, 13.01.2026	-	Independent Work on Developing Solutions
13	Di, 20.01.2026	08:00-11:30	**Workshop - Pitching your Solution**
14	Di, 27.01.2026	-	Independent Work on Developing Solutions
15	Di, 03.02.2026	08:00-11:30	**Final Presentations (Assessment 3)**

Examination

The project examination comprises three assessments.

Overview of the Assessments

Assessment	Assessment Weighting	Type of Assessment	Deliverables
#1: Problem definition	10%	Group	Materials for presentation
#2: Solution concept and prototype	20%	Group	Materials for presentation
#3: Project report and working solution presentation	70%	Group	Written report, materials for presentation

Assessment 1: Problem definition
Students formulate their problem statement, including motivation and relevance. The problem definition should include the type of innovation and stakeholders, possibly the range of technologies involved. Students present their findings in an appropriate format.

Assessment 2: Solution concept and prototype
Students formulate their solution concept. Presentations show the proposed digital technology solution. An integral part is the description of the group's development approach and project plan. Feasibility tests and prototypes, schematic diagrams, mock-ups, and other useful forms of early design should be included. Students present their work deliverables in an appropriate format.

Assessment 3: Project report and working solution presentation
Students write a detailed report of their project. The working solution is described and adequately presented. The assessment consists of two parts: (1) the project report and (2) the presentation of the working solution.

All assessments are due on the day before the presentation at 23:59 via ILIAS.

Introductory Reading Materials and Resources

Resources:

- Fairphone (website): https://www.fairphone.com/en/
- Fridays for Future (website): https://www.fridaysforfuture.org/
- General Public License (GNU) – free, copyleft license for software and other kinds of works: https://www.gnu.org/licenses/gpl-3.0.en.html
- HardwareX Journal (website): https://www.journals.elsevier.com/hardwarex
- Stackshare.io (website): https://stackshare.io/
- United Nations, Sustainable Development Goals Agenda (website): https://sustainabledevelopment.un.org/?menu=1300
- Wakawaka (website): https://waka-waka.com/en/

References:

Ferdoush, S., and Li, X. 2014. "Wireless sensor network system design using Raspberry Pi and Arduino for environmental monitoring applications," *Procedia Computer Science* (34), pp. 103-110.

George, G., Merrill, R. K., and Schillebeeckx, S. J. 2020. "Digital sustainability and entrepreneurship: How digital innovations are helping tackle climate change and sustainable development," *Entrepreneurship Theory and Practice* (45:5), pp. 999-1027.

Langdon, P. 2015. "Vertical Hydroponic Farm." from https://create.arduino.cc/projecthub/bltrobotics/vertical-hydroponic-farm-44fef9?ref=platform&ref_id=424_respected___&offset=2

Oberloier, S., and Pearce, J. M. 2018. "Open source low-cost power monitoring system," *HardwareX* (4).

Pocero, L., Amaxilatis, D., Mylonas, G., and Chatzigiannakis, I. 2017. "Open source IoT meter devices for smart and energy-efficient school buildings," *HardwareX* (1), pp. 54-67.

Qureshi, I., Pan, S. L., and Zheng, Y. 2021. "Digital social innovation: An overview and research framework," *Information Systems Journal* (31:5), pp. 647-671.

Spinelli, G. M., and Gottesman, Z. L. 2019. "A low-cost Arduino-based datalogger with cellular modem and FTP communication for irrigation water use monitoring to enable access to CropManage," *HardwareX* (0:0).

Tasic, V., Staake, T., Stiefmeier, T., Tiefenbeck, V., Fleisch, E., and Tröster, G. 2012. "Self-powered water meter for direct feedback," *2012 3rd IEEE International Conference on the Internet of Things*: IEEE, pp. 24-30.