University of Cologne

Faculty of Management, Economics and Social Sciences

Cologne Institute for Information Systems (CIIS)

Chair of Information Systems and Systems Development

Sustainable Digital Innovation Lab (Systems Engineering for Digital Innovations)

Course Instructor(s)

- Dr. Janek Richter
  https://www.is4.uni-koeln.de/de/team/post-doctoral-researchers/dr-janek-richter/

Registration and Contact

Due to limited course capacity available, please contact janek.richter@wiso.uni-koeln.de in advance if you are interested in enrolling to the course.

COVID-19 Situation

The upcoming Winter Semester will likely be run in a hybrid form with online courses for larger groups and allowing physical presence in small seminar formats. The course is planned in a seminar format with team interactions in presence and joint development of the physical artifacts. Lecturing units and presentations will be offered in an online format. Depending on the pandemic situation during the semester, team projects may have to be simulated as distributed development projects (meaning that physical meetings may not be possible for student teams). We are observing the situation closely and will gear towards the University's recommendations.

Goals of the Module

Students …

… understand what digital innovation means and learn about important related concepts.

… learn about potentials of emergent digital technologies.

… understand challenges related to designing information systems for digital innovations.

… develop an idea for a digital innovation by incorporating latest digital technologies.

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

… organize themselves and work in independent teams.

… manage time, team, and project conflicts independently.

… communicate processes and outcomes to relevant stakeholder groups.

Content

In this unit, we simulate a project-based digital innovation lab. The objective is to develop a novel digital solution to a chosen sustainability innovation challenge. With this objective, we have two specific foci.

1. Address a Sustainability Innovation Challenge

We define a sustainability innovation challenge as a problem of either environmental or social but not primarily commercial value (George et al. 2020; Qureshi et al. 2021). As inspiration, consider the *Sustainable Development Goals of the United Nations* that provide a set of goals and agenda for peace and prosperity. Another source of inspiration for environmental sustainability innovation challenges is the *Fridays for Future* movement that emerged from school strikes demanding action to prevent further global warming. As a concrete project example consider the *Fairphone* – a highly modular smartphone that accounts for conflict-free production resources, worker welfare and e-waste programs – or *Wakawaka* – a solar-powered lamp providing 16 hours of reading light on less than a day of sunlight. What we do not consider as sustainability innovation are, for example, lean manufacturing approaches that are directed to primarily increase efficiency in production processes and which may include reduction of waste only as a side effect. Another negative example are greenwashed products and practices that make unsubstantiated or even misleading claims about their environmental benefits (e.g., reducing the carbon footprint). Our goal here is to help students understand both grand sustainability challenges that concern current and future generations. We seek to advance students' understanding of the solution potential of information systems 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 that students can choose to work with. The students' task is then to develop a software solution for the hardware technology stack such that a digital innovation can be realized. To illustrate, consider these examples:

- Vertical Hydroponic Farm Arduino Project (Langdon 2015)
- Self-powered water meter for direct feedback to 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:

- Introduction to digital innovation
- Grand challenges and wicked problems of a sustainable society
- Selected emergent digital technology stacks
- Systems development practices suitable for complex contexts and requirements
- Project and team management
- Design and implementation of information systems
- Prototyping and Testing

Procedure

Students will form teams to complete this unit. In teams, they are free to choose their problem settings to be addressed within their digital innovation project. A selection of hardware technologies will be available at the beginning of the course to start experimentation right away. Team formation is scheduled for the kick-off session. In advance, students are encouraged to familiarize themselves with some preparation material and fill out a brief survey that can be used for team formation. During the semester, students will be able to use a fixed budget to buy additional hardware components such as sensors, extensions, motors, tools etc. for their projects on an as-needs basis. Orders have to be issued through the course instructors.

Over the course of the semester, student teams will continuously work on developing their digital innovation solution. The course will include a range of accompanying help and assistance formats including lectures, tutorials, and interactive workshops. For the workshops, students are 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 under a free and open-source design solution that meets the requirements of a professional outlet such as *HardwareX* – an open-access journal established to promote free and open-source designing, building and customizing 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. As compatible open-source license model, we recommend the *General Public License (GNU).*

Technology Stack

We provide students with hardware technologies, which can be used to start experimentation and trial from the beginning. The following list should be understood as a guide for starters and not as a comprehensive list of technologies that can be used.

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

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

Time Slot and Room

Due to the pandemic situation, we will most likely not be able to physically meet. However, we have booked classrooms throughout the semester and are evaluating whether they can be used for small teams. The rooms are located in the Pohlighaus (https://www.is4.uni-koeln.de/de/contact/). For the events, please refer to the schedule.

Examination

The portfolio examination comprises three assessments.

Overview of the Elements of the Portfolio

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 description including motivation and relevance. Problem definitions should already address the type of innovation and stakeholders, possibly the realm of technologies involved. Students present their deliverable in an adequate format.

Assessment 2: Solution concept and prototype

Students formulate their solution concept. Reports address the planned digital technology solution to serve as a blueprint. An integral part is the description of the group's development method and project plan. Feasibility tests and prototypes, schematic diagrams, mock-ups, and other useful forms of early design should be included. Students present their deliverable in an adequate format.

Assessment 3: Project report and working solution presentation

Students formulate a detailed report of their project. The working solution is described and adequately presented. The assessment comprises two parts: (1) the project report and (2) the presentation of the working solution.

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.

Schedule

Week	Date	Time	Topic
1	Wed, 13.10.2021	09:00-12:00	*Kick-off Workshop* Lecture part: • Introduction to course topic • Organization & procedures • Resources Workshop part: • Team formation • Playful exploration of technologies Deliverable(s): • Team formation • Technology setup
1	Thu, 14.10.2021	10:00-17:00	*Initiation Workshop* Lecture parts: • Guest lectures for inspiration and problem scoping • Lecture with details about hardware technologies Workshop parts: • Problem scoping techniques • Wrap-up & learnings Deliverable(s): • Topic selection • Problem scoping

1	Fri, 15.10.2021	10:00-13:00	*Ideation Workshop* Lecture parts: • Introduction to digital innovation • Wicked grand challenges Workshop parts: • Systemic Ideation • Design thinking techniques Deliverable(s): • Problem formulation • Solution ideating
4	Thu, 04.11.2021	10:00-11:30	Presentation of Problem Definitions (Assessment 1)
4	Thu, 05.11.2021	10:00-11:30	Conducting User Research using Personas
7	Thu, 25.11.2021	10:00-12:00	Presentation of Solution Concepts (Assessment 2)
11	Thu, 13.01.2022	10:00-13:30	Pitching your Solution
13	Thu, 27.01.2022	10:00-13:30	Final Presentations (Assessment 3)