Towards the design of an interactive continuing training for software engineers in the Internet of Things sustainability using the example of autonomous vehicles

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***Abstract*—The Internet of Things (IoT) is related to a large variety of challenges that need to be addressed before it can be implemented in an organization. One of the most crucial upcoming challenges is sustainability. This includes impacts on the environment, security, ethical, and economic aspects. Therefore, an interactive continuing training on the Internet of Things sustainability will be implemented. The training is based on a real-world case study in the IoT domain of autonomous driving. The learners get the opportunity to verify sustainability factors as preliminary work for a test automation project in an IoT environment. Within the case study, they take on distinctive roles of decision-makers responsible for sustainability issues. Finally, they work out a corresponding requirements specification book in the course of a group assignment.**

***Index Terms*—Internet of Things, sustainability, autonomous vehicles, interactive continuing training, quality assurance**

I. Introduction

The immense increase in the number of Internet-connected devices comes at a time when reducing resource and power consumption and reducing radiation exposure are top priorities. In the meantime, more and more connected devices have a considerable impact on sustainability. On the one hand, the application of IoT devices can contribute significantly to the fight against climate change through the realization of innovative technologies. On the other hand, this is also related to a variety of contrary effects. Examples, therefore, are radiation exposure and tremendous power consumption.

The challenge is to verify the sustainability effect on the IoT devices and environments that are used both in professional and private life.

IoT users need a guideline for a sustainable application. This concerns the entire range of devices incorporated with IoT technology, from house devices via healthcare products up to connected vehicles. The main feature of such devices is that they are equipped with sensor technology. According to [1] the most important sustainability factors in software engineering are environmental sustainability, ethical sustainability, and economic sustainability, as depicted in 1. An example of environmental sustainability is the optimization of energy consumption. A solution on how individual devices can lower their transmission rate without affecting the performance of the services is described in [2]. An example of social and ethical sustainability are data protection aspects. As described in [3, p. 34], data collected on IoT devices can generate contextually related information. It needs to be verified that in any case, the owners of the devices remain in charge of their data at all times, even when external parties get temporary access to it to perform specific tasks. For this purpose, ethical aspects are of high significance. A typical example, therefore, is the behavior of autonomous vehicles in case an accident is unavoidable. Furthermore, information on the driving behavior can be collected over time and transmitted to insurance companies [4, p. 684 ff.]. Finally, also economical aspects need to be considered. This means references to software engineering in IoT environments, for example, the implementation of a sustainable test (automation) environment. This includes a mitigation strategy including maintainability and expendability aspects to reduce running costs for customization. To raise awareness of persons who are working in IoT-related domains, especially as software engineers, software quality engineers, and continuing education trainers in these areas, a proposal for continuing training as preliminary work for comprehensive continuing training on software test automation for autonomous vehicles will be implemented. The goal of this study is to develop training that addresses the expectation of professionals to become educated in the environmental, ethical, and economic aspects of IoT technology using autonomous and connected vehicles as an example. Therefore, a proposal for project-oriented continuing training is provided.

This study is organized as follows. In Section 2, the research objectives and research questions are defined. In Section 3, a systematic research on related learning units and related research papers is conducted. Therefore, first, a short introduction to the individual learning techniques applied in the respective studies will be given. Subsequently, in the first stage, corresponding scientific conferences and journal papers , and, in the second stage, academic and industrial curricula, are analyzed. In Section 4, an approach for an appropriate interactive training to elaborate a requirements specification book for environmental, ethical, and economic sustainability aspects is presented, that will finally be handed over to a quality assurance team to implement a test automation infrastructure for autonomous vehicles in the course of a follow-up training. In Section 5, the research questions defined in Section 2, will be evaluated. Section 6 concludes this study with the lessons learned from the learning design, especially the benefits of the course in comparison to similar courses. Finally, Section 7 gives a brief outlook to a follow-up training on test automation of autonomous vehicles that builds on the results elaborated in the course of the training presented in this study.

II. Research Objectives

Within the scope of this study, current approaches to continuing training on IoT sustainability discussed at scientific conferences and in scientific journal papers will be analyzed. The most important criterion is that these papers are based on a real-world case study. Moreover, existing curricula on IoT sustainability will be analyzed. Furthermore, it will be analyzed if the curricula are based on a concrete case study and on which learning technique(s) they are based. Based on the findings of these analyses, a proposal for training on IoT sustainability will be designed that needs to be completed in a learning group of four persons.

A. Research Questions

RQ 1 - What primary challenges of IoT sustainability (environmental, ethical, economic) are discussed in scientific conferences and journal papers? Are the papers based on a real-world case study and on which learning technique(s) do these case studies focus?

RQ 2 - What primary challenges of IoT sustainability (environmental, ethical, economic) are discussed in scientific and industrial continuing training curricula? Are the curricula based on a real-world case study and on which learning technique(s) do these case studies focus?

RQ 3 - What are the most important aspects that are required for successful further training of professionals in IoT testing on the example of autonomous and connected vehicles? What contents a training on IoT sustainability should include and how it should be structured?

The research questions are answered based on the sustainability aspects depicted in 2. Therefore, the sustainability model proposed in [1] will be applied. Ethical and social sustainability are summarized.

B. Learning Techniques

The expectations of professionals on continuing training are depending on their knowledge and their professional experience. The Dreyfus model of skill acquisition defines five different phases. These are *novice*, *competence*, *proficiency*, *expertise* and *mastery* [5], [6, P.190 ff.]. While career starters usually follow a predefined learning path, individual expectations for further training increase with professional experience. People with extensive professional experience usually ask themselves why they should attend continuous training. They expect to benefit from it as well in their day-to-day work as also in terms of their future career.

It will be analyzed which learning type(s) the papers and the learning units focus on. Therefore, the following three types are existing [7]:

- Subject-centered
- Problem-centered
- Learner-centered

Subject-centered learning is mainly applied in traditional classroom education at primary, middle, and high schools. It is usually aligned with a given curriculum that is valid for a long period, up to a few years [8].

Problem-centered learning focuses on a special topic the learners need to be trained on so that they can solve it subsequently [9].

Learner-centered learning focuses on the individual needs and preferences of the learners [10], [11], [12], [13], [14]. In this regard, learner-centered learning best addresses the Dreyfus model by taking into account the individual requirements of each learner.

III. Related Work

To analyze previous research in IoT sustainability, a systematic literature review has been carried out. The scope were papers that focus on environmental, ethical, and economic sustainability. Furthermore, corresponding learning units that focus on IoT sustainability aspects have been analyzed. On the foundation of the outcomes of the reviews, a proposal for an interactive learning unit for professionals in the field of software engineering, especially software quality engineering, has been defined.

A. Related Conferences and Journal Papers

1) Observation and Analysis of Environmental Factors of Surface Waters: An Internet of Things Educational Approach [15]

   The paper describes a case study that was applied in regards too STEM[1] education at high schools. The students have the opportunity to experience what they

[1] STEM: Science, Technology, Engineering, Mathematics

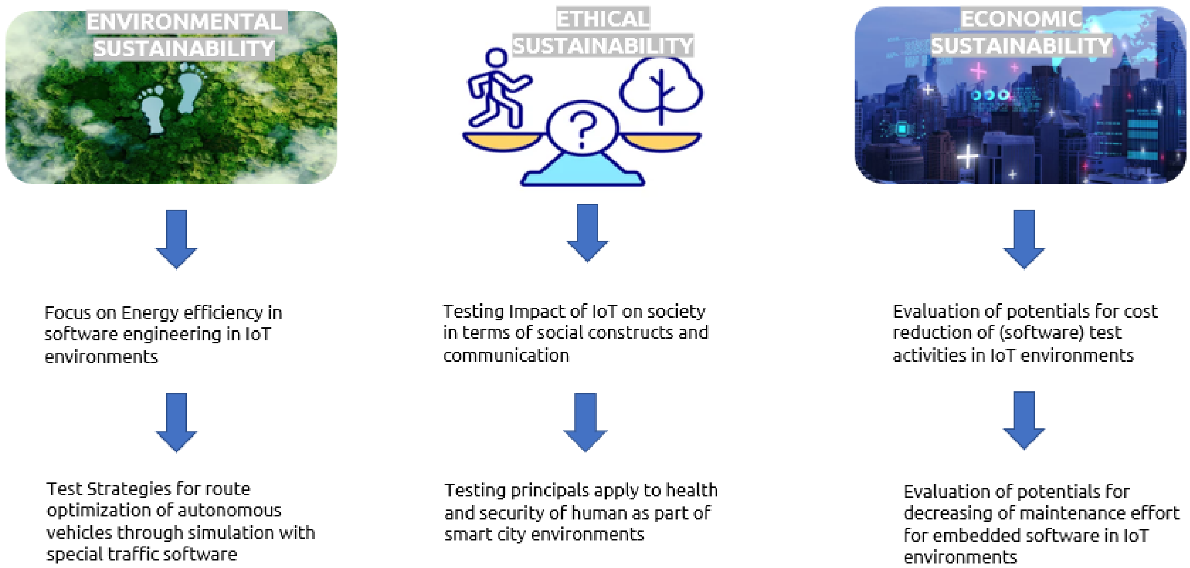

Fig. 1: IoT sustainability aspects

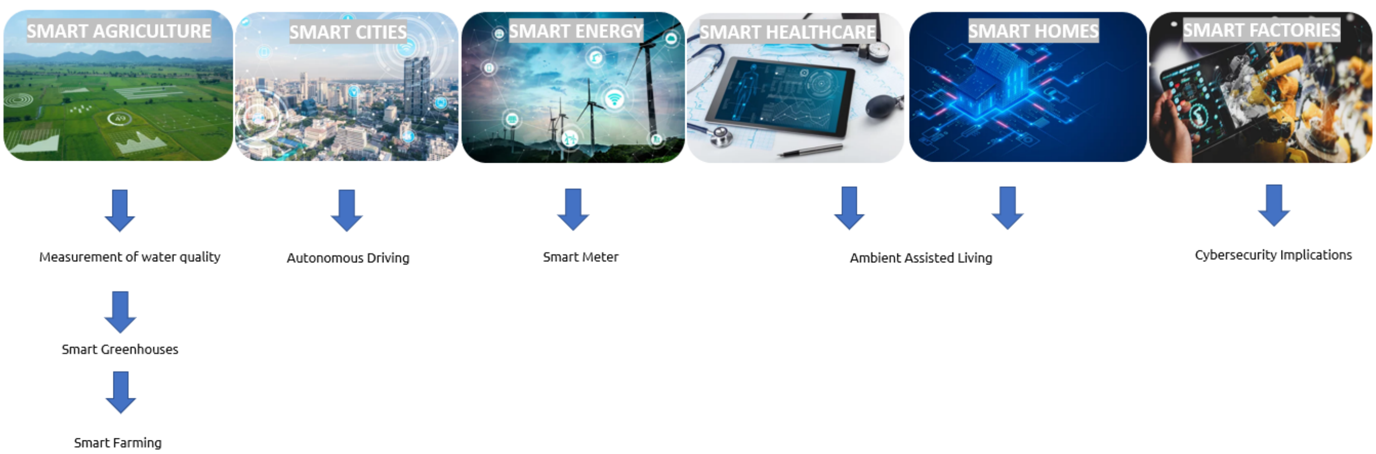

Fig. 2: IoT application domains

learned in a laboratory. This enables problem-centered learning. The case study focuses on a specific topic, the measurement of water quality. Furthermore, the students have the opportunity to carry out scientific experiments by themselves under the instruction of a teacher. Considering the learners are still novices in their respective fields of application, they accept a given learning path.

2) Blending Problem-and Project-Based Learning in Internet of Things Education: Case Greenhouse Maintenance [16]

This study is based on a case study in which students develop IoT device prototypes to improve the cultivation of greenhouses. This enables problem-centered learning. The assignment focuses on a specific topic, the maintenance of a greenhouse. The students have the opportunity to experience the learning content interactively. The students are still at a novice level in this domain. This means that they usually accept a given learning path.

3) Analysis of the Learning Effectiveness of the STEAM-

Title	Conference/Journal	Case Study	Subject-centered	Learner-centered	Problem-centered	Sustainability Dimension(s)
Observation and Analysis of Environmental Factors of Surface Waters: An Internet of Things Educational Approach [15]	2019 First International Conference on Societal Automation (SA)	Yes	No	No	Yes	Environmental
Blending Problem- and Project-Based Learning in Internet of Things Education: Case Greenhouse Maintenance [16]	SIGCSE '15: Proceedings of the 46th ACM Technical Symposium on Computer Science Education	Yes	Yes	No	No	Environmental
Analysis of the Learning Effectiveness of the STEAM-6E Special Course—A Case Study about the Creative Design of IoT Assistant Devices for the Elderly [17]	Sustainability 2018, 10, 3040	Yes	No	Yes	Yes	Ethical
Integrating the Concept of Industry 4.0 by Teaching Methodology in Industrial Engineering Curriculum [18]	Processes 2020, 8, 1007	Yes	No	Yes	No	Ethical, Economic
Academic/industry educational lab for simulation-based test and evaluation of autonomous vehicles [19]	Proceedings of the 2018 Winter Simulation Conference	Yes	No	Yes	Yes	Ethical, Economic

Table I. Conference and Journal Papers on Internet of Things sustainability

Institution	Course Designation	Case Study	Subject-centered	Learner-centered	Problem-centered	Sustainability Dimension(s)
The Mind Lab, Auckland, New Zealand	Internet of Things (IoT) and Sustainability Future Lab	No	Yes	No	No	Environmental, Ethical
Environmental Campus, Birkenfeld, Germany	IoT²Werkstatt IoT²Werkstatt	Yes	No	No	Yes	Environmental, Ethical
BSI Group, London, United Kingdom	Internet of Things (IoT) Fundamentals Training Course BSI Group	No	Yes	No	No	Environmental,Ethical
La Trobe University, Melbourne, Australia	Master of Internet of Things La Trobe	No	Yes	No	No	Environmental , Ethical

Table II. Curricula on Internet of Things sustainability

6E Special Course—A Case Study about the Creative Design of IoT Assistant Devices for the Elderly [17]

The target group of this study are trainees in the field of nursing and geriatric care. The study focuses on a specific problem. The livability of elderly people should be increased through IoT devices. The learners have a legitimate interest to apply the experiences of this training in their future occupational routine. This means that a strictly given learning path is not accepted anymore. So, both problem-centered and also learner-centered learning are applied.

4) Integrating the Concept of Industry 4.0 by Teaching Methodology in Industrial Engineering Curriculum [18]

This study was conducted in 2020 with accompanying research in the Industrial Engineering program at King Saud University in Riyadh, Saudi Arabia. The program offers students the opportunity to experience smart product manufacturing techniques in a learning factory. This is an example of learner-centered training. The students use the learning factory to experience for themselves the optimal learning strategy to reach their learning objective with a focus on the field of activity in which they intend to work in future. This approach can also contribute to the development of new technical innovations by students and, as a consequence, the establishment of new start-up companies.

5) ACADEMIC/INDUSTRY EDUCATIONAL LAB FOR SIMULATION-BASED TEST AND EVALUATION OF AUTONOMOUS VEHICLES [19]

This study has been implemented within the scope of an academic and industry alliance. The target audience are students in the final stage of relevant graduate and undergraduate programs. The lab provides them with an opportunity to experience day-to-day tasks in a real-world project to facilitate the transition from university to the workforce. The students get access to a virtual environment. Within this virtual environment, a refocus of the test environment is provided, so that the students can immediately focus on testing techniques and don't need to care about the development of the physical vehicle and the installation of the embedded software. They learn through virtual and augmented reality. This is an ideal approach for learning how to test embedded software in autonomous vehicles in a simulated environment, as the architecture and used techniques are already largely identical to a physical test environment, and as a consequence, making the transition to testing in physical environments much easier. This is a typical example as well for a problem-centered as also for a learner-centered approach.

B. Related Curricula

1) **IoT sustainability- Future Learn, The Mind Lab, Auckland, New Zealand**
The training focuses on environmental and data privacy aspects. Environmental aspects are demonstrated in the example of smart farming.
Each lecture ends with a discussion. The discussion consists of one open question for each individual learning unit. However, the answers don't need to focus on any criteria.

2) **IoT²Werkstatt, Environmental Campus, Birkenfeld, Germany - The sustainable Internet of Things**
The *IoT²Werkstatt* offers a learning module on the *Sustainable Internet of Things*. It is demonstrated in a case study on energy consumption.
Another learning module, is offered on *data privacy*. In this learning module a software sensor for humans to identify the number of connected devices in the local environment is demonstrated in the course of a case study. The students get an introduction to coding with Ardublock[2].

3) **BSI Group, London, United Kingdom - Internet of Things (IoT) Fundamentals Training Course**
The course focuses on the main cybersecurity implications of IoT. Furthermore, an introduction to the potential implications of the General Data Protection Regulation (GDPR) on IoT is given.
All in all, the curriculum focuses on ethical and social sustainability and covers one of the three sustainability dimensions defined in [1].

4) **La Trobe University, Melbourne, Australia - Master of Internet of Things Professional Environment**
The La Trobe University offers a Master's program in Internet of Things. The program includes both a module on *professional environment*, and *security and privacy in IoT*. In the module on *professional environment* students develop professional skills in ethical and moral decision-making. Active participation in group discussions and activities are required.
In the module on *security and privacy in IoT*, the students learn about security and vulnerabilities in IoT architectures, threats to access control, privacy, and availability, authentication/authorization for smart devices, security, and privacy issues in IoT, security in IoT cloud platforms, confidentiality and security concerns in IoT applications and ethics of developing end-to-end IoT solutions.
All in all, the curriculum focuses on all of the three main sustainability dimensions defined in [1].
However, the target group are graduate students and work-based learning is not possible.

[2] Ardublock:http://blog.ardublock.com/

The IoT application domains the evaluated papers and curricula focus on are depicted in 1.

IV. Design of the Learning Unit

The scope of this section is the design of the curriculum for the course. The primary objective is to convey awareness of the importance of sustainability factors. The training imitates a real-world situation. To realize this, it is essential that the training includes a case study. Furthermore, it needs to be customized to the current knowledge and experience level of the learners. While subject-centered curriculum design is mainly used for the design of school subjects, e.g. mathematics, computer science, physics, chemistry, biology, geography, or languages, learner-centered and problem-centered curriculum design is rather suitable for the design of continuing training in software quality assurance with a focus on IoT. Learner-centered curriculum design is applied to design curricula that are customized to the individual needs of the respective learners. Problem-centered curriculum design is applied to curricula that support professionals to solve specific problems as easily as possible. This can be, for example, an analysis of security and privacy risks or energy consumption of IoT devices. For our target group, both individual needs and problem-solving competencies are of paramount importance. Therefore, a combination of a problem-centered and a learner-centered approach is most appropriate. Professionals should raise awareness of the importance of sustainability by analyzing it in the context of a case study on autonomous vehicles. Therefore, as well environmental, ethical as also economic factors concerning sustainability need to be considered . The curriculum is based on the sustainability model presented in [1]. Thereby, social and ethical sustainability factors are combined. Ethical factors such as the behavior of the AV in a dilemma situation have also effect on the general acceptance of society.

A. Course Principles

The course targets the following goals and outcomes related to sustainability factors of software testing in IoT environments on the example of autonomous and connected vehicles:

- The course must be aligned with the expectations of software quality assurance professionals.
- The course needs to build on a case study that reflects a real-world situation within an IoT quality assurance project.
- The course needs to build on the foundations of professionals in software quality assurance.
- The workload needs to be manageable so that it can be completed in a foreseeable period alongside the job commitments of the participants.
- After completion of the course, the attendees need to be able to refer to the outcomes in the course of real-world engagements in test automation in the area of autonomous and connected vehicles.

The decision on this IoT application domain was taken because it is a highly topical issue. Not only car manufacturers, but also automotive suppliers, technology, and service providers, and even a variety of start-ups are confronted with this topic. Concerning our target audience, software quality engineers, the International Software Testing Qualifications Board (ISTQB) provides certification as Certified Automotive Tester [20][3]. Furthermore, this topic will probably accompany society at least for the next couple of years, possibly also over the coming decades. The reason for this is that the embedded software of vehicles must be constantly updated, thus each component must be tested again after a new release, and ultimately the effort involved must be as sustainable as possible.

B. Course setup

1) Learning Targets: After completing the training, participants will be able to assess the impact of IoT on sustainability and initiate appropriate measures in the course of a real-world project. They can define requirements specifications regarding environmental, ethical, and economic factors.

2) Teaching Approach: The skills are taught on the example of a case study on autonomous vehicles. This is one of the fastest-growing IoT domains. After a short introduction to the basics of autonomous driving by an experienced instructor, a team consisting of two to four persons will be built to solve a case study interactively. In the course of the case study, each of the course participants is assigned to an individual role. The roles to be assigned are environmental representative, test manager, internet security officer, and ethical advisor, as depicted in 3. The individual tasks of the roles are as follows:

Environmental representative : The environmental representative defines principles the quality assurance team needs to consider before the implementation of a testing environment in a follow-up training. This includes the definition of test cases that evaluate behaviors of self-driving vehicles that contribute to energy saving. This can be realized if the autonomous vehicle is able to choose the shortest path from point A to point B. In a further context, this can also contribute to avoiding the construction of new roads that are often related to considerable interventions in local recreation areas, longer travel distances, reduction of housing space, and land sealing. But it is also related to adverse effects on the environment. One example, therefore, is the production, recycling, and re-use of batteries. Another challenge is radiation exposure.

Test manager : Within the scope of this training the test manager is responsible for the planning of a long-living test (automation) environment. This includes the evaluation of appropriate technologies and tools. Furthermore, the owner of this role is responsible to define a mitigation strategy including the definition of maintainability and expandability aspects during the design of a test framework. If changes to the system under test are considered, aspects of testability must be taken into account to verify their technical and economic sustainability.

Information security officer : According to [21], attacks on autonomous vehicles are classified into the following three categories: attacks in the autonomous control system, attacks on autonomous driving system components, attacks on vehicle-to-vehicle and vehicle-to-everything communications. The information security officer is responsible for the implementation and coordination of an internal information security management system on the foundation of internationally established standards as ISO 27001[4], TISAX[5], CISM[6], CISA[7], CISSP[8] or T.I.S.P.[9]. As part of this training, he or she needs to define the security guidelines as part of the requirements specification book that will subsequently be handed over to the software quality assurance team. This must cover the most important safety criteria of autonomous vehicles.

Ethical advisor : IoT is related to a variety of ethical aspects. The reason, therefore, is that machines perform tasks that were carried out by humans so far.

[3] ISTQB CT-AuT: https://www.istqb.org/certifications/automotive-software-tester

[4] ISO 27001: https://www.iso.org/isoiec-27001-information-security.html

[5] TISAX: https://portal.enx.com/en-us/TISAX/

[6] CISM: https://www.isaca.org/credentialing/cism

[7] CISA: https://www.cisa.gov/

[8] CISSP: https://www.isc2.org/Certifications/CISSP

[9] T.I.S.P.: https://www.teletrust.de/en/tisp/

Fig. 3: Course Setup

In the worst case, the action of a machine can make the difference between the life and death of a human. An autonomous vehicle can, for example, get into a situation where there are only two options, either heading for people or heading for a precipice. The condition for a test case in such a situation could be to perform the action that is predicted to pose the least risk to human health and life.

Each individual learner fills out one of the four individual roles. The team defines requirements specifications that cover the following sustainability factors: Environmental, ethical, and economic sustainability. The intention is to provide continuous training that can be completed asynchronously. This means that it is possible to attend it from any place in the world at any time. After the introduction to the basics of autonomous vehicles and sustainability in IoT environments, the learners analyze individual IoT sustainability factors within their assigned roles.

The training should be implemented by applying an agile approach with regular sprints at defined points in time. The intention, therefore, is that all course participants, independently of the role they fill out during this training, should be aware that for IoT testing all these factors have the same priority and they should be able to communicate with professionals in these functions at a technical level. The learners should be able to define a sustainability strategy by themselves. The learners need to analyze in a group what are the most important sustainability factors they need to consider and define a requirements specification book as a foundation for a follow-up training on test automation in IoT environments on the example of autonomous vehicles. Each course participant can work independently within his or her role with free time allocation. The final goal is to collect the results of each course participant, analyze and evaluate them in a plenary session and finally merge it into a requirements specifications book that will finally be handed over to the test automation team. The instructor interacts in the background in the role of the engagement manager. He or she only intervenes in the case one or more learners consult him or her.

V. Results

A. Evaluation of the Research Questions

RQ I - What primary challenges of IoT sustainability (environmental, ethical, economic) are discussed in scientific conferences and journal papers? Are the papers based on a real-world case study and on which learning technique(s) do these case studies focus?

In complete, five scientific conferences and journal papers have been analyzed. All of the analyzed studies incorporate a case study. Three of these approaches include a case study based on a real-world situation. One of the papers describes a subject-centered learning approach, one a learner-centered approach, one a problem-centered approach, and two both a learner-centered and a problem-centered approach. Two of the papers focus on environmental sustainability, and one on ethical sustainability, two both on ethical and economic sustainability. The target audience of the study that builds both on a learner-centered and a problem-centered approach and ethical sustainability are apprentices in health care. The target audience of the two studies that focus on environmental sustainability, whereby one study focuses on a problem-centered approach and the other one on a subject-centered approach, as well as the study that focuses on both ethical and economic sustainability and builds on a learner-centered approach, are students at high schools. The target audience of the study that focuses on ethical and economic sustainability and builds both on a learner-centered and a problem-centered approach are graduate and undergraduate students in the transition from university to the workforce. Two papers focus on the application domain of smart agriculture, thereof one study focuses on the measurement of water quality and another one focuses on cultivation in smart greenhouses. One paper focuses on the application domain of smart healthcare, concretely on ambient assisted living. One study focuses on the application domain of smart factories, especially smart product manufacturing, and one on smart cities and mobility, especially autonomous vehicles. A comparison of the analyzed papers is depicted in *Table I*.

RQ II - What primary challenges of IoT sustainability (environmental, ethical, economic) are discussed in scientific and industrial continuing training curricula? Are the curricula based on a real-world case study and on which learning technique(s) do these case studies focus?

Furthermore, four curricula of universities and private course providers have been analyzed. Only one curriculum includes a case study. Three of the curricula describe a subject-centered learning approach, and one is a problem-centered learning approach. All of the curricula focus as well on environmental and ethical sustainability. Furthermore, one focuses on economic sustainability. One study focuses especially on the application domain of smart agriculture, with reference to smart farming. One curriculum focuses on the application domain of smart energy, with reference to energy consumption. Two studies focus on the application domain smart industry, with reference to cybersecurity implications. A comparison of the analyzed papers is depicted in *Table II*.

RQ III - What are the most important aspects that are required for successful further training of professionals in IoT testing on the example of autonomous and connected vehicles? What contents a training on IoT sustainability should include and how it should be structured?

In complete, six professionals in the field of software engineering, software quality engineering, and IT training in the course of a user experience test, were interviewed. The goal of these interviews was to find out with what learning approaches learners with different prerequisites due to prior knowledge and professional experience are most comfortable with. Especially young professionals expect clear step-by-step instructions to solve a case study successfully. They want to know explicitly where to start and what exactly are the expected results. At least the most important sustainability aspects *environmental*, *ethical*, and *economic* sustainability, need to be covered. Therefore, the training should be completed in a group of four people, whereby each individual takes on a specific role. These are the role of the *environmental representative*, who is responsible to define environmental sustainability aspects that need to be covered in test cases, the *test manager*, who is responsible for the planning of a sustainable test (automation) environment, the *information security officer*, who is responsible for the definition of a security guideline that covers the most important safety criteria of autonomous vehicles and finally the *ethical advisor*, who is responsible to define and prioritize ethical aspects as part of the testing strategy. The prerequisite for the learners to be able to complete the training successfully is that each individual course participant is picked up at his or her current level of knowledge and experience. Therefore, it is essential to provide a model-based curriculum with customized on-demand learning modules that fill knowledge gaps of each individual based on an interactive, hands-on approach instead of video trainings or classic frontal classroom trainings.

B. Lessons Learned

This training fulfills all aspects that are required for an interactive IoT learning platform. It reflects a real-world engagement and is based on a case study on autonomous vehicles. Classic classroom training as well as theoretical video training is avoided. Joachim Buxel, Regional Sales Manager for the DACH [10] region at Checkmarx, outlined in an interview with the ASQF SQ Magazine in September 2020, that such trainings are to a great extent decoupled from day-to-day work and are of little or no benefit. Instead of this, an interactive and practical-oriented approach needs to be considered. Software engineers need customized trainings with a clear context to their day-to-day work. This leads to a higher learning factor as well as diminished training costs. The training can be incorporated as a building block in a modular curriculum. It can be customized in a short time to new requirements of individual learners or an individual project.

VI. Conclusion

In this study we analyzed existing research and curricula to identify the potential for training that fills the gaps in these studies and as a consequence fulfills all requirements of customized continuing training on IoT sustainability with a focus on autonomous driving for software

[10]DACH: Germany, Austria, Switzerland

engineers and software quality engineers. The decisive factors for continuing training in IoT sustainability are that the trainings are based on a realistic case study, the definition of the target audience according to the Dreyfus model, and finally the respective sustainability dimension. For professionals, it is important that an incorporated case study the training builds on is based on a problem that the target audience is confronted with in relevant projects. With this approach, professionals can recognize an added value for themselves, and why they should participate in the training. The learners get the opportunity to experience by themselves opportunities to provide a sustainable project environment. Within the case study, they take on distinctive roles of decision-makers responsible for sustainability issues. Finally, they will work out a requirements specifications book in the course of a group assignment.

VII. Future Work

This training serves as a preliminary stage for follow-up training performed by a quality assurance team of a fictitious IT service provider. The team is responsible for performing hardware and software integration tests, vehicle/software integration tests, module integration tests, and vehicle prototype tests in a virtual lab on the foundation of the requirements specification book elaborated in the course of this training. In the lab, all required tools, frameworks, simulators, and components will be incorporated. It will be accessible via an online learning platform. The test object of this training is a robotic vehicle simulated on a Gazebo simulator in Robot Operating System [22]. This follow-up training will also be conducted in the course of a group assignment. The learning group in this training consists of test automation engineers, and a test manager. The instructor will interact in the role of the engagement manager. He or she is responsible for the entire project and is the first point of contact for the customer.

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