Service Learning with Impact: How Engineering Students and People with Disabilities Acquire Future Skills

Abstract— **This Paper presents a new service-learning setting based on the collaboration of engineering students and people with disabilities. The implementation at a German university is described and first results from two years of experience are shown. The objective of this case study is to show a transferable best practice concept with impact.**

Keywords— Service Learning, Inclusion, FabLab, People with Disabilities

I. Introduction

In the second year now, in collaboration with sheltered workshop of the Diakonie, computer science students in their third semester and students from other engineering subjects can participate in the service-learning program within an embedded systems module. The aim of the collaboration between university and Diakonie is to promote defined future skills of both students and disabled employees. The employees have a maximum work ability of thirty percent physically, mentally or physically and mentally. Including a university FabLab as a “toolbox” for digital fabrication the students are enabled to realize their ideas in form of prototypes and products. The results are overwhelming and the feedback of students and people with disabilities is highly promising.

The concept is based on two aspects: First, the often formulated need for future skills in society, and second, the growing responsibility of universities in cooperation with a wide set of partners to address wicked problems with a transformative approach. They led to the following question: How can we respond to this within the regular system of teaching and learning?

The following paper describes the structure and implementation of the service-learning concept in a typical engineering course. Additionally, it provides a special focus on benefits for students and users - in this case people with disabilities.

It starts with the description of the theory-based teaching-learning concept based on the assumptions of impact by service-learning. The special place of production, a FabLab, is introduced. Some selected results are presented and evaluated. Finally, strengths and weaknesses of the concept are investigated. They are summarized in the part conclusions. Additionally, a foresight on possible connections to entrepreneurship education will be formulated.

II. Research Questions

In this case study we combine a service-learning concept with a FabLab as a “toolbox“ for rapidly creating prototypes and products. This seems to be an ideal environment for meaningful and satisfying learning with impact for our students and for the cooperating people with disabilities.

Our main research questions focused on these two target groups are:

Students

F1.1: How can motivational design, service-learning and a FabLab be combined to support implementation-oriented learning in an embedded systems course?

F1.2: Is it possible to create useful and sustainable prototypes for and with people with disabilities in one semester?

F1.3: Are we able to identify additional competences beyond the classical embedded systems module based on the product results?

People with disabilities

F2.1 Is it possible to arouse the interest and motivation of people with disabilities with a maximum work capacity of thirty percent to participate in projects based on digital technology?

F2.2: Does this kind of service-learning has any sustainable benefit for people with disabilities?

III. Theoretical Background

This section introduces to the main-theories the authors used to implement a motivational course concept with impact.

A. Motivational Design

The course concept is based on the ARCS (Attention, Relevance, Confidence, Satisfaction)-model of motivational design by Keller [1]. The main categories, definitions and process-questions are shown in table 1. The motivational design, as Keller understands it, represents the bridge between the theoretical study of motivation and the practice for increasing or changing the motivation of people. On one side of the bridge are concepts, theories, and principles from their study of human motivation, and on the other side are procedures, successful practices, and design processes that have resulted from the work of designers and practitioners whose aim is to improve learners motivation.

Major Categories and Definitions		Process Questions
Attention	Capturing the interest of learners; stimulating the curiosity to learn	How can I make this learning experience stimulating and interesting?
Relevance	Meeting the personal needs/ goals of learner to effect a positive attitude	In what ways will this learning experience be valuable for my students?
Confidence	Helping the learners believe/ feel that they will succed and control their success	How can I via instruction help the students succed and allow them to control their success?
Satisfaction	Reinforcing accomplishment with rewards (internal and external)	What can I do to make my students feel good about their experience and desire to continue learning?

Table 1: ARCS: categories, definitions and process questions. According to „Motivational Design for Learning and Performance: The ARCS Model Approach (p. 45) von J. M. Keller, 2010, Springer US.

The process model (Fig.1.) illustrates how curiosity/ attention of a person and the personal motives and values (relevance) in interaction with the confidence in success determine the goals with the highest priority and lead to targeted effort [2].

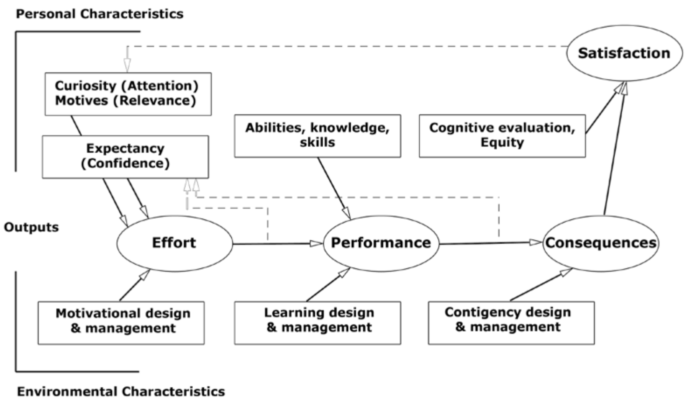

Fig. 1: A macro-model of motivation, learning, and performance. According to „An Integrative Theory of Motivation, Volition, and Performance," by J. Keller, 2008, Technology, Instruction, Cognition, and Learning, 6, p. 83.

Environmental characteristics, shown below, and personal characteristics influence whether or not this effort remains goal-oriented and leads to an increase in performance contribution. Personal performance, combined with the type of reinforcement or feedback, determines the consequences of the effort in terms of whether the expected outcome was achieved. These consequences, in combination with a cognitive self-evaluation and reflection have an effect on the satisfaction with the process and the results.

This causes a feedback, indicated in the model by dashed lines, which influences the next cycle run positively or negatively. The personal perception of the relationship between effort and increase in performance, and between the increase in performance and the consequences are linked to the personal expectations and changes them. The degree of satisfaction is in turn dependent on personal motives and values, so that the value of a given goal increases or decreases. Our service-learning concept catches the interest of students by stimulating it with the possibilities of a FabLab to rapidly realize self-invented ideas. Working with and for people with disabilities and creating meaningful results support the relevance for the students, especially because their prototypes and products will be used in daily life. Using digital fabrication tools and the direct and individual support by coaches strengthen the confidence of students. Presenting the result in an open fair and getting positive feedback from citizens and experts, as well as knowing that the people with disabilities will be happy to use the products in their everyday work and life, gives satisfaction.

B. Service-Learning

The service-learning method provides a framework to integrate the above-introduced approaches and to implement them in the real classroom setting. The centrepiece constitutes the defined task: The student teams have to collaboratively develop digital assistance systems for and with real user (on this case the cooperating people with disabilities) to support their everyday work and life. Student teams and users had to match self-initiated projects during the organized kick-off event.

Service Learning describes formats that facilitate the acquisition of specialist knowledge by its practical application for the solution of real social problems. The resulting experiences lead to a reflection, which in turn leads to a deep understanding of the subject [3]. In contrast to standard course conceptions the methodological applications and the implementation of a project under the restrictions of the reality (e.g. specific requirements of the clients) are added to the learning of subject content.

Additionally, the context of the individual acquisition of knowledge and action are extended by the integrated social context. The work creates added value [4]. The competence acquisition in Service Learning settings differs to other learning activities through the experience-based approach linked with reflection in an iterative process. It can be described in the style of the Experiential Learning Spiral according to Kolb by a permanent passing through the phases: (practical) experience/observation, reflection, finding a solutions theoretically, practical application, etcetera [5].

Due to the holistic orientation, the learning arrangement promotes the integrated acquisition of competence in the dimensions of personality development, collaboration and leadership (importance of personal and social responsibility, commitment, respect and empathy), the acquisition of specialist knowledge and the critical handling of existing knowledge [6]. The quality of the reflections has a decisive influence here [7]. Transferred to the level of concrete curriculum planning, there is thus the possibility to extend the learning outcomes of the expertise by the ability of practical application and personality development/soft skills [8].

C. *Implementation of the project-oriented teaching and teaching*

Service-learning can find its way into teaching in various forms. In the presented best-practice example, the integrated acquisition of competences, in the sense of service learning, is achieved through the development of an individual electronic assistance system for and with a person with disabilities.
A conception as a project-oriented module is therefore obvious. Project-based teaching describes courses in which learning content is acquired by working on definable projects.

According to Holzbauer et. al. it is only in the context of projects that learners are given the opportunity to experience themselves as experimental and effective designers of transformation processes. In this so-called project learning, they take on tasks that expand their experience and knowledge. More than that, they develop new mental models and knowledge structures simply by confronting different values, norms, opinions, perspectives and proposals of all those actively involved [9].

The product- and result orientation, the meaning and reflection of the learning and work progress, the participative acquisition of knowledge and the holistic approach of technical and social learning through application are included in both approaches and therefore make a profitable combination possible.

According to Holzbaur et. al. the fundamental prerequisite is the definition of the project goals: Vision (the future state), mission (the task to be completed) and deliverables (the products to be delivered) [9].

Significant adjusting screws for the teaching concept are:
- Practical relevance: authentic problem definition that corresponds to teaching objectives
- Methods of project management: Project management as teaching content
- Student autonomy: approx. 10% teaching instruction. As a result of the paradigm shift from teacher- to student centered learning
- Student participation: joint, active project work
- Cooperation within the team: Project work can only be structurally successful within the team
- Student-driven process: students have the choice of adequate problem-solving strategies and priorities
- Monitoring: the success of the project is observed
- Suitable form of examination: combination of product- and process-oriented elements [9].

D. Learning resources

Learning resources in general include all the services available for the acquisition of knowledge. They are of particular importance in project-oriented teaching because they are a self-directed and problem-oriented learning process and, as already mentioned, the proportion of pure teaching instruction is very small. Schreiner et al. (2015) refer to a broad spectrum of expert lectures or impulse lectures on the generation of orientation knowledge, technical discussions, contact persons and project requirements, or scripts and brochures with content compilations[10]. Furthermore, references to peer learning are obvious. In addition to collaborative knowledge production and implicit peer teaching and learning taking place in the project teams, targeted promotion is also conceivable [11].

IV. THE LEARNING ENVIRONMENT

At the centre of the entire learning concept is the FabLab as a physical production facility. It is flanked by various learning approaches. The main focus is the task within the module "Embedded Systems“. The Diakonie with its sheltered workshop supports the students as a service-learning partner. Cooperation agreements are signed between Diakonie´s employees and students to signal commitment and to support a sense of responsibility. As an intended result the students and their user become a development team.

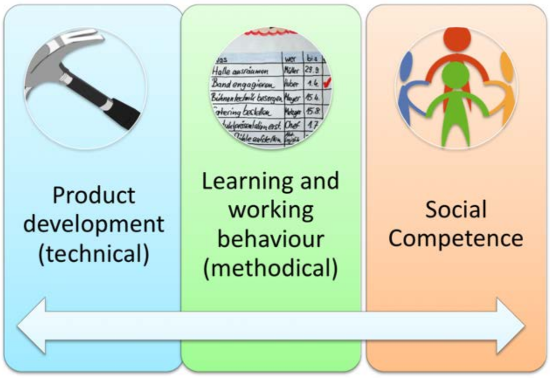

Fig. 2: Integrated competence acquisition

Reflection diaries shall visualize the status quo of group dynamics, project development and the relationship between the students’ team and the collaborating user and thus make it negotiable. Group coaches supervise their groups at various levels. From technical problems to communication difficulties, they are looking for ways for the groups to solve occurring problems on their own, to overcome frustrations and develop important soft skills. Initially, subject-specific teaching units were delivered to all students of the module. In the course of the semester project they were transformed into simultaneously held problem-oriented teaching inputs. In addition, all teaching inputs were provided with Moodle as learning management environment for more differentiated learning. An ePortfolio and a MediaWiki (OER) serve as a sustainable documentation of the project development and learning process as well as for the participation of others (fig. 3).

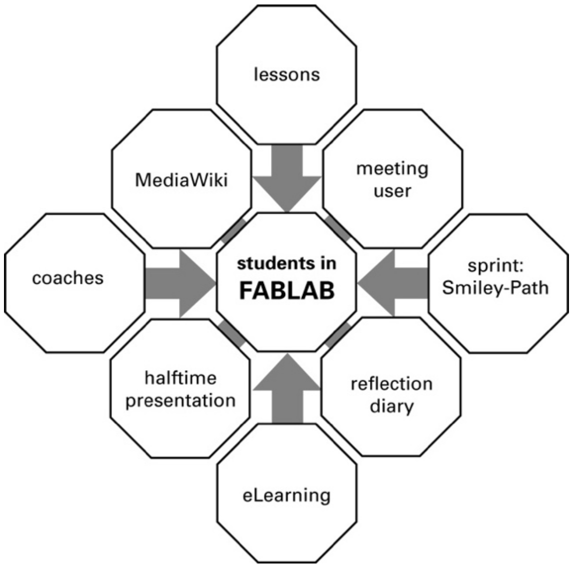

Fig. 3: The concept from the students' perspective

During the project development, also the users should experience added value in a structured way. The main aim is to reduce technology anxiety and experience of self-effectiveness. Depending on the individual attitude and willingness, the employees of the sheltered workshop can only observe the active colleagues during the lifespan of the project. In this way, the interest in active participation and digitalization may also be awakened. Through the protected framework of the university project, they can actively participate in the development of a new product as feedback-giving users and get in touch with digital technology through discussion and interim evaluations. According to the motto of the UN Convention on the Rights of Persons with Disabilities (UN-BRK) "Nothing about us without us!", the spirit of comprehensive participation of civil society is taken into account [12] and thus promotes an exchange between students and people with disabilities on an equal footing. Inclusive thinking and acting is expected on both sides (fig. 4).

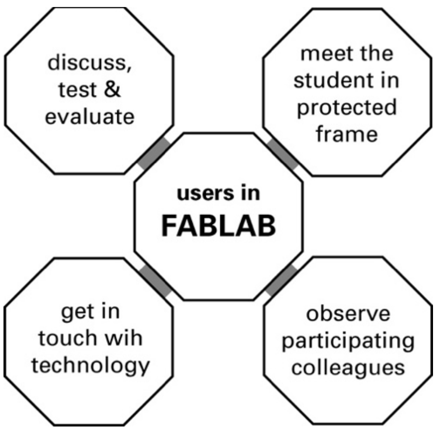

Fig. 4: The concept from the user's perspective

A. HRW FabLab as a physical production facility

FabLabs, the maker movement and the ideas derived from it, such as real laboratories, learning and experimenting spaces, were initiated by Neil Gershenfeld at the Massachusetts Institute of Technology (MIT). With his seminar "How to Make (Almost) Anything" in 2005, he laid the foundation for a rapidly increasing number of FabLabs worldwide (currently more than 1900) [13].

In 2012 the HRW FabLab was founded and was further expanded as 3D Competence Centre Niederrhein as a merger of FabLabs in Kamp-Lintfort, HRW and RWTH Aachen. Currently, these Fablabs are among the best equipped and most active in the world.

In this service-learning course this “digital fabrication environment” with more than thirty 3D printer, lasercutter, electronic development paces etc. is used for rapidly and easily creating prototypes and products.

An essential feature of the labs is the interdisciplinary exchange of knowledge, information and ideas. Funk shows that in such labs innovation processes are accelerated, access to fresh ideas is realized, willingness to take risks is increased, talents are recruited, employee motivation is improved and positive effects on innovation culture are a result [14].

V. Implementation

The following flowchart shows the phases of our embedded system course (fig. 5).

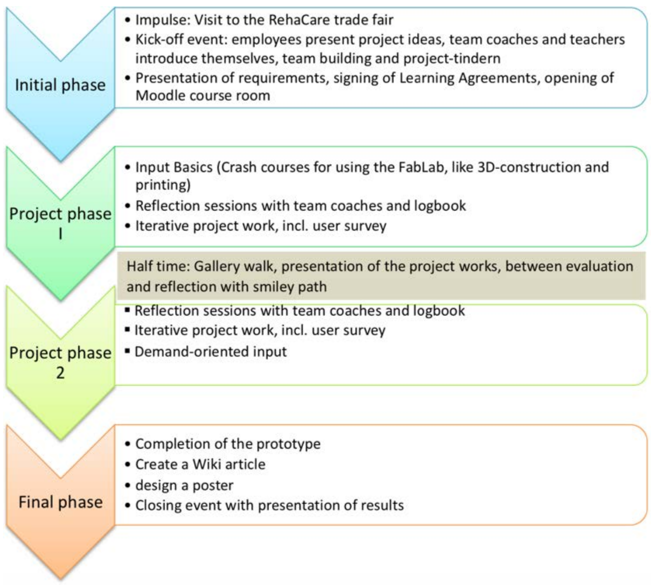

Fig. 5: Flowchart of the implemented service-learning concept for embedded systems

Initial phase

In the initial phase, after the sensibilization of the students through the visit of one of the most relevant fares in this sector (Rehacare), the student and employees with disabilities are welcomed (fig. 6) in a kick-off-event.

In this event they get a general impression of what to expect by the presentation of the course concept and the results of the former course. Afterwards all nominated coaches present themselves, their background and their special expertise. As a kind of inspiration-giver, the staff member of the Diakonie and employees of the Diakonie present yet unsolved problems in the daily life and work for people with disabilities / themselves.

Fig. 6: Opening and welcome of new students. Sandner, J. (Photographer), 2019.

Finally, it's time for the participants to match self-initiated in teams with students, users and coaches, to create a first working title for the project idea, share contact details and to document all this with the subscription of the shared learning agreement (fig. 7).

Fig. 7: Discussion between people with disabilities and students. Klöpfel, J. (Photographer), 2019.

Project phase I

At the end of the first half-time it is time for a multi-level check. Does the project idea work out? Are working style and methodology appropriate?

These questions are addressed by a self-critical group presentation of the status quo with constructive feedback by the plenum and a midterm evaluation tool called smiley-path. The smiley path provides a tool for critical self-reflection. The team assesses its own status and defines if and which changes are necessary for a timely successful project completion.

Project phase II

In this phase, students concentrate on completing their working prototype/product. It is a stressful phase for the students in which they are accompanied by their coaches and receive input from the FabLab staff if desired.

Final phase

In the final phase the results are presented on an open fair (fig.8).

Fig. 8: Impressions of the closing fair after one semester. Sandner, J. (Photographer), 2019.

The students present their functional prototypes. For the exam, they present their results orally using a self-created poster and an extensively documented wiki article and receive their grades.

VI. Evaluation of the results

Since the teaching concept described above includes tasks that result in tangible prototypical products, it is appropriate to analyze these results. For this purpose, some preliminary considerations are taken into account. Technology is not autonomous [15]. The development of electronic assistance systems is always a product development. Product development of electronic products has to deal with the problems and the design of the human-machine interface, since it aims at the human being as user. The task of designing the human-machine interface belongs to the field of industrial design and is linked to the following interdisciplinary topics: the task and the justification for its processing, the development of a concept, the necessary means for its implementation, the search for the technical solution, the perceptibility, the message and comprehensibility of the product, the usability, the economic efficiency, the aesthetics, the social and ecological justifiability and the integration of several design requirements [16]. Due to the special task of developing assistance systems for and with people with disabilities, rehabilitative pedagogical approaches, thoughts of inclusion and sociological aspects are also part of the project. This is only an incomplete list and depends on the individual project.

Another special point makes an analysis of the product results appear promising. It is the disability perspective as a driver of innovation. For example, the invention of the typewriter is based on an originally developed communication aid for blind people. In addition, "cross-functional" effects can be observed at the historical course of the interface between design and disability. These are design approaches that do not see the disability as an addressee of the development, but rather use it as a starting point for further context-independent areas of application. For example, the steam-guided plywood bending technology for modern wooden furniture was originally developed from an order placed by the US government with the Eames design couple. They were to design lightweight and stable leg splints for war-disabled people. Conversely, Braille for the blind was first developed as a system for transmitting messages for Napoleon's troops [17]. Cross-functional thinking is thus a skill that goes beyond the boundaries of one's own discipline.

In the context of a typical embedded systems module, teaching units were including microcontroller programming, control of actuators and sensors and programming for wireless control (Bluetooth), app programming for Android and iOS. In addition there was a brief instruction in form-finding processes, an introduction to the method of documentation at MediaWiki and individual support for technical problems by our coaches. Seminars were held in digital production methods such as 3D printing and laser cutting. This was the technical toolbox that the students received as input.

With reference to the questions posed above, selected results are evaluated below. The following aspects have been taken into consideration:

a. transdisciplinarity,

b. notes on user-centered solutions

c. user involvement in the development process

d. innovation content or other added value

Finally, a comparison example in which these aspects do not occur is shown.

In the following, some projects in their setting of tasks are described and the results are highlighted on the basis of the aspects specified above.

A. *MORPHEUS - 360° collision warning for wheelchairs*

Fig. 9: Project-logo invented by the user

The task, which the group set itself in cooperation with the user, a spastic paralyzed employee of Diakonie, had several subtasks:

- On the one hand, the wheelchair should be equipped all around with sensors in order to offer collision protection as well as to warn against falling levels, e.g. kerbs, staircases.

- On the other hand, the user wanted to be able to adjust the distance warning depending on the situation.

- Furthermore, due to the spastic paralysis of the user, the warning system had to function in such a way that the user was given environmental control in every situation. He should therefore be able to receive either an acoustic or an optical signal.

- The task was aggravated by the fact that the user was only sent by the employer to the regular project meetings if the collision warning system was applicable for each type of wheelchair. The multiple benefit for colleagues who were not involved was considered.

- Due to the limited mobility of his fingers, the user insisted on a mobile phone control. Together with him, they designed and programmed the user interface as an app.

- Finally, the system had to be permanently powered and integrated into the wheelchair.

Fig 10: left: User with application on his wheelchair. Sandner, J. (Photographer), 2019; right: Screenshots of the Morpheus-App

The well thought-out installation of the battery with charging function and the carefully thought-out wiring show an intensive intrinsically motivated examination of the function, folding mechanism and safe use of the e-wheelchair and the elements to be installed.

These questions are typically not included in classical embedded systems modules, since they fall into the area of product development and thus require a transdisciplinary thought process.

The sensors are equipped with exchangeable clip fasteners so that they can be easily converted to other types of wheelchairs. It has been designed in a product system, thus increasing its usability.

The system solution and the integration of the employer's requirements into the development show typical development steps to a classical marketable product development. First approaches of an entrepreneur-mindset can be seen here. Classical embedded systems modules of the third semester of the bachelor study do not contain cross-competence requirements in the teaching concept.

Fig. 11: Wheelchair, adding components. Klöpfel, J. (Photographer), 2019.

The built-in battery with an external USB port for convenient charging and the carefully laid and thought-out cabling demonstrate a user-centric approach and a concern with the safety aspects of operability and the laying of cables with moving elements.

Here, aspects of ergonomics, electronics and mechanical engineering were independently integrated into the thought processes, arising from the problem. This do not occur in classic embedded systems modules.

Fig, 12: Display for collision detection. Fig. 12a: Klöpfel, J. (Photographer), 2019. Fig. 12b: Sandner, J. (Photographer), 2019.

Visual control unit and app control were developed in close exchange with the user and show approaches of inclusive design and ergonomics. The integration of the user's designs and ideas into the product development shows the serious interest of the students in the applicability and an actual use of the product in daily life.

Classic embedded systems formats typically do not include the ability for intrinsically motivated, user-centric product development with the goal of actual, immediate application.

B. *MAJA - Desk blood glucose monitoring system*

Fig. 13: MAJA, outline

Maja uses an ESP32 module to read the Freestyle Libre Sensor mounted on the diabetic's arm. The aim of the project was to read the measured blood glucose values and to make them visible for the user and his environment even in situations of distraction and activity. It make them controllable at any time. The shape of a turtle was chosen as a symbol of long life, friendliness and wisdom. Its shell glows green when the values are OK and red when they should be controlled. Since the turtle stands on the table, it does not need a battery and can be connected to a PC, for example.

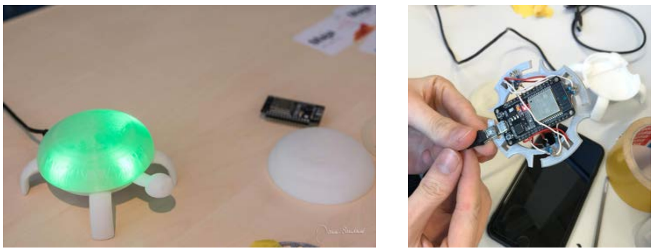

Fig. 14: MAJA, left: view in operation. Sandner, J. (Photographer), 2019; right: circuit board integration. Konopek, A. (Photographer), 2019.

Two special aspects that go far beyond classic embedded systems modules are particularly noteworthy: On the one hand, the group has intensively dealt with the integration of the circuit board and the electronic components, as the turtle is only the size of a hand. On the other hand, the group was faced with the delicate legal issue of liability for malfunctions in medical products. Intensive research was carried out here, as the group wanted Maja to be used. The students consciously decided to develop Maja as an additional control unit. It should only be possible to recommend that the diabetic should check his own blood sugar levels. This product is not yet available on the market. The innovation potential is high. Right now the group is trying to get support for start-ups within the framework of the university support programmes.

C. *CardMaster Extreme - card game engine*

Fig. 15: Cardmaster Extreme Logo

This card game was the wish of a young man in a wheelchair due to spastic paralysis. Together with the group, he explained his problems with card games and actively participated in its development as a feedback-giving user and co-thinker. This product is also to be promoted as part of the university's StartUp programme.

As in the project described above, the task is divided into subtasks:

- since the user cannot take individual cards from a deck, the game must be able to do so.
- The cards in the card deck must be accessible to all players at the table.
- Since the user can hardly use and adjust the device himself, the basic settings of the game, such as the number of players, must be adjustable beforehand.
- The aim was to develop an immediately applicable and functional prototype.

The concept of the game is simple and new: with a game app "CardMaster Extreme" on the mobile phone, the user sets the number of players and the number of cards to be issued. Depending on the number of players, the device knows how many degrees it has to turn. 3 players = 120°. Once the user has placed his card, he presses a large orange button that is easy for him to reach. The device turns and hands out the next card.

Fig. 16: CardMaster Extreme, left: App determine the number of players. Konopek, A. (Photographer), 2019: right. product in action. Sandner, J. (Photographer), 2019.

A more detailed market research revealed that this game solution does not yet exist. The innovation potential is obvious. Classical embedded systems modules do not include market research in the teaching concept. This is a typical competence of industrial designers.

The development of the mechanics for the individual card output required a lot of time. The setbacks in development demanded typical soft skills: frustration tolerance. In classical teaching methods try-and-error is not intended as a learning method.

The game shows aspects of inclusive design and ergonomics and falls within the classic remit of product designers. The very user-centered development also allows a game with several participants who are physically impaired. The intensive examination of the physical conditions of a spastic paralysis touches competences from the field of rehabilitation pedagogy and can be recognised by the user-friendliness of the app, the well-functioning card distribution for handicapped people and the very easy-to-operate button.

Typical learning contents of the embedded systems module do not deal with rehabilitation pedagogy or inclusive approaches. The output technology is a purely mechanical solution and shows design thinking processes that have gone through, resulting in an intelligent simple solution. In classic embedded systems modules, design thinking processes are usually not part of learning.

The design of the logo shows the own conviction of the project and the will of a professional, marketable appearance. This aspect falls within the field of communication design.

In classic embedded systems modules, questions of marketing are usually not part of the class.

D. *Smart Bedwetting Alarm*

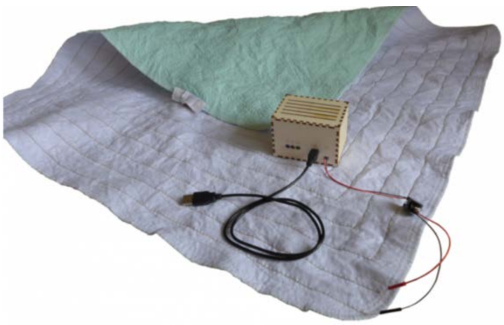

Fig. 17: Bedwetting Alarm. Students (Photographer), 2019.

The client of this product was an employee of the nursing service. As soon as the mat becomes damp, it sends a message via Bluetooth to the mobile phone of the nursing staff. The difficulty was to find the moisture threshold between simple sweat and urine. The staff does not have to check regularly or the bedridden person does not have to lie in the wet for a longer period of time.

The special feature and the absolute added value lies in the mobile app and the costs. Such a mat usually costs 100-200 Euro, too expensive for the nursing service. The material costs of the mat developed by the students are 20 Euro. In addition to the user-centered development to relieve the nursing staff, the claim was to actively work against the high costs in nursing.

In classic embedded systems modules, business management skills are not usually taught.

Finally, the analysis of the project results shows the following:

The classical contents of the embedded systems module are taught through teaching units and eLearning. A project developed on this basis has basically passed.

Transdisciplinary competence developments in the areas of industrial design, communication design, project management, rehabilitation education, mechanical engineering and mechatronics, business administration, medical law and ergonomics are primarily intrinsically motivated. They are triggered by the new teaching concept and an encounter with the user at eye level.

In classic embedded systems modules, business management skills are not usually taught.

For comparison, a project is shown to meet the minimum requirements. Even in classic embedded system modules there are differences in the quality of cabling and programming. The highly complex, transdisciplinary development of an applicable product for and with an active user does not belong to it.

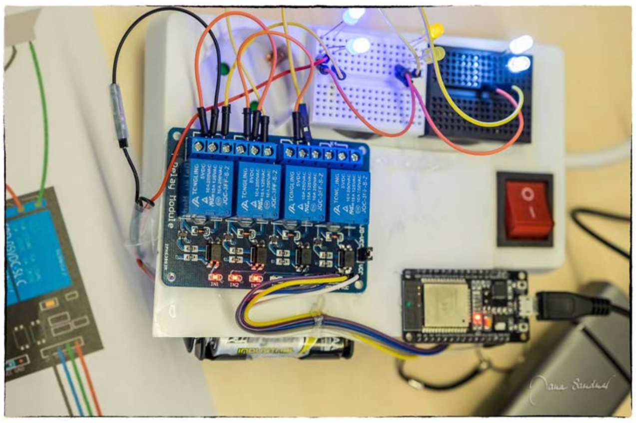

Fig. 18: Bluetooth controlled switch. Sandner, J. (Photographer), 2018.

VII. Conclusion

At this point we only deal with the research questions in chapter II, a basic evaluation was published in conference proceedings: “Tagungsband zum 4. Symposium zur Hochschullehre in den MINT-Fächern“ [18].

In this paper we have explained the structure of the course concept and its implementation. Based on the product results it is clearly visible that far beyond classical courses, product developments have been self-motivated and indicate a successful combination of motivation design, service learning and a FabLab.

In the first cycle 16 prototypes/products were created from originaly 19 project groups. Four of these are currently in concrete use within the Diakonie. Two further projects are to be transferred into start-ups. This shows that it is possible to develop sustainably usable products within one semester.

As described in detail in Chapter VI, the students had to deal with an intensive user-centered view and real problems and conditions of a sheltered workshop. The analysis of the products described above led to the perception that direct conclusions can be drawn about additionally acquired competencies on the basis of design features.

While in the first cycle only two employees with disabilities of the sheltered workshop were actively involved, the interest in the next cycle increased, so that the number of participants had to be limited to five employees with disabilities.

"I consider the cooperation with the students and the users of our workshop to be very valuable. The exchange brings new experiences for both sides and helps develop social skills. The results have already become very good. But they should aim to make the results usable. Unfortunately many projects were not completed.", citation of the head of digital working environment.

Furthermore, it could be established that an interest in active participation was awakened solely on the basis of the observation of one's own active colleagues.

It can be stated that the teaching concept can generate added value for the employees with disabilities of the Diakonie in two respects. Four prototypes are currently still in use. Furthermore, at least two employees with disabilities visit the FabLab frequently to develop their own products now. One of them is mentally impaired.

VIII. SUMMARY AND OUTLOOK

In principle, a promising concept was implemented. However, not all expectations could be met in the second cycle, because the success of the first cycle seems to increase the expectations.

Furthermore, sustainability must be ensured, since often at the end of the semester the prototypes/products do not fully meet the desired requirements and function. This is to be achieved in particular through follow-up projects and the initiation of start-up projects. For this purpose, HRWStartUp is established as basic organizational structure for start-up support. Prototypes and products can be introduced by the students and further developed until they are ready for the market and transferred to start-ups.

A framework for monitoring digital competencies and their changes is being developed and will be tested in the next cycle.

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