ROBOdidactic 2.0 – the journey and perspectives of a tech-didactic model

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Abstract

This paper presents the update of ROBOdidatic. ROBOdidactic is a practice-based and practice-directed tech-didactic model for designing and evaluating courses with digital production.

The non-normative model offers inspiration and methods within 4 dimensions: teaching design, digital production, digital literacy and the environment for the courses. Its 21 elements are outlined concretely in guidelines and can be selected in a didactic framework. The model has been tested and is now in early use in secondary education as well as in transition courses between upper primary to secondary education.

ROBOdidactic vs. 2.0 is the current result of an agile process, undertaken as community action research in an adaptive and participatory project design. 3 mutually independent projects with different timelines were used for this purpose: crossingIT (2017-2019), ROBOlearning (2018-2021) and ARducation (2020-2022). At the same time, synergies between the projects were achieved.

The next steps will be transforming ROBOdidactic into an app with augmented reality, visualizing course examples from the 3 projects. Teachers will experience the app in teacher training, while they will plan courses with digital production, among other things with augmented reality.

International interest in the work is increasing, and new partnerships, together with new emerging technologies, will challenge teaching design as we know it today, once again.

Keywords

Course design, teaching design, digital production, digital literacy, didactics, agility, adaptive project management, participatory project management, community action research

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Introduction and context

The ´future world of work´ is not the future anymore. Digitalization and automation affect our lives in, roughly speaking, all fields. Industry 4.0, welfare 4.0 and commerce 4.0 have prompted education 4.0 and 21st century skills.

Denmark is one of the most digitalized countries in Europe (DESI, 2019), with broad strategical and practical progression on all levels. The VET colleges and vocational high schools operationalize their visions based on local digitalization strategies, and among other things, they continuously try to integrate technologies as they emerge in society and in the trades.

In the Danish education sector, innovation projects are spearheads exploring possibilities, limitations and methods for implementing new technologies and digital structures. In best cases, the results from the public innovation projects are designed as generic models that become freely available and can be adapted by next users under their own local conditions.

In this context, several recent innovation projects in Denmark have resulted in and promoted the tech-didactic model "ROBOdidactic". Version 1.4 of ROBOdidactic was presented in 2019 at ECEL, the 18th

European Conference on e-Learning (Majgaard et al, 2019). Since then, ROBOdidactic has been further developed to version 2.0 in an action research process (a. o. Senge et al, 2001; Majgaard, 2011). This article outlines the process with the milestones of this journey and new perspectives that have emerged.

ROBOdidactic was developed, tested and further developed in 3 different projects in Southern Denmark:

- ROBOlearning[1] (2018-2021) about robots in learning processes, conducted in 9 public educational institutions
- crossingIT[2] (2016-2018), implementing programming in teaching at different levels, conducted in 7 vocational high schools in each their own Southern Danish municipality
- ARducation[3] (2020-2022), exploring augmented reality and its commercial potential, in 3 vocational institutions in 3 municipalities, involving up to 10,000 pupils and students

All projects are characterized by teaching with the use of digital production. These courses take place in the teaching of specific subjects, as well as in interdisciplinary teaching in secondary education and across educational levels. Peer-to-peer learning processes and teacher-to-teacher co-creation and coordination are particularly present in the courses conducted across educational levels. Mutual understanding of learning processes, didactics and learning products, is crucial.

´Courses with digital production´ in the above-mentioned context do not require a specific duration, number of students, educational subjects or choice of specific technologies. However, in any case the courses must refer to the given learning outcomes required of the students according to educational regulations. Thus, the courses are part of the given educational program that the students are enrolled in.

Courses can have many different forms. They can be short introductory tutorials for a new technology or interdisciplinary technological learning projects with theme relevant to society, or they can be major tech competitions involving many schools. In most courses of the courses conducted in the 3 projects, the students created their own digital learning products. But courses can also focus on the students´ reflections on digitalization and its impact on human life and society.

Questions

All of the circumstances and processes outlined above led to the following questions:

1. Which principles and elements should be considered, when designing courses with digital production?
2. How can teachers communicate across professional fields regarding these courses?
3. Finally, how can developers approach the creation of a guiding didactic model?

ROBOdidactic, a tech-didactic model

To update the reader: ROBOdidactic promotes a teaching design that includes digital production, whether the technologies cover programming, robot technologies or emerging technologies such as augmented reality (Majgaard et al, 2020). The teaching of technological production is linked to aspects of digital literacy, as well as to collaboration with stakeholders in the environment of the educational institutions.

Iterative methods (Sharp et al, 2019) on the one hand, playground approaches on the other hand (Christiansen in Gudiksen et al, 2020) and the learners' co-design of processes are some of the distinctive elements in the model.

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[1] ROBOlæring https://www.robo-sydfyn.dk/ , Region Southern Denmark
[2] CrossingIT http://www.crossingit.dk/ , Region Southern Denmark
[3] ARducation https://arducation.dk/, Region Southern Denmark

With a consistent student-centered approach, the teachers create coherence across educational levels, between primary, secondary and higher education. Thus, the teachers cooperate across the levels to transform the ´education chain´ into a ´learning chain´: "from ´ABC to PhD".

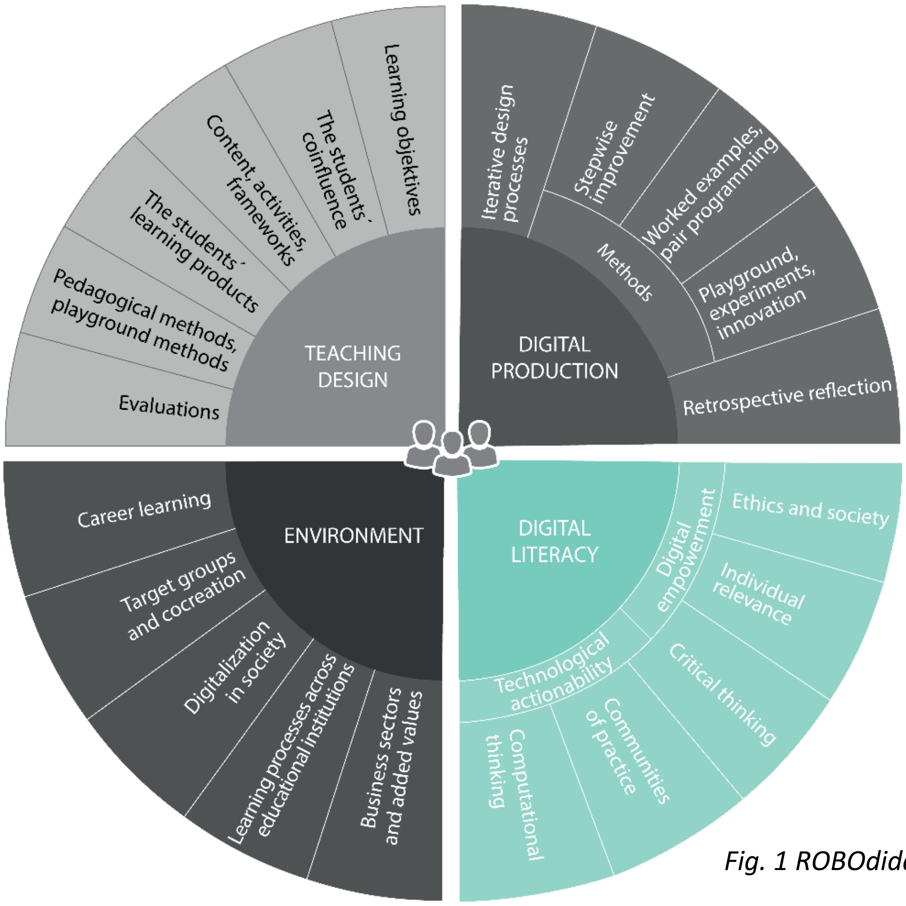

Fig. 1 ROBOdidactic 2.0, 2020

See Majgaard and Lamscheck-Nielsen (2019) for a more detailed outline of ROBOdidactic vs. 1.4.

Since its version 1.4, the results from a number of different tests and reviews have been manifested in the model´s circle shape with its 4 basic dimensions and their crucial elements to aid teachers in designing courses with digital production. After reviewing the model in a more in-depth and detailed process, some of the elements were revised, and some new elements were added; for example, playground methods (Gad Christiansen, 2020) achieved a more explicit status (fig. 1).

In addition, new detailed, thorough guidelines were created. The guidelines explain the different elements and offer ´guiding questions´, operationalizing the model and increasing its applicability in teaching practice.

The model can be accessed anywhere, and the development of new courses can be initiated from any of the 4 dimensions or from one of the elements. ROBOdidactic is not a hierarchical model, nor does it determine the process. The model offers inspiration and promotes reflection, without dictating how to prioritize or interpret its dimensions for local application.

Outcomes of the process and current status

ROBOdidactic is currently in "early operation". It is used among the practitioners – teachers as well as managers – from the 3 projects crossingIT, ROBOlearning and ARducation. In addition, the model has been applied by Majgaard, SDU, in several workshops and seminars for other teachers. ROBOdidactic has also received a certain amount of attention from Danish and international researchers in the field of ICT-didactic.

The application has its competitors and limitations, as well. ROBOdidactic cannot replace local didactic models, frameworks and systematic course descriptions at colleges, high schools and primary schools in general. The Danish VET colleges and vocational high schools are self-governing and decide autonomously on local pedagogy and didactic, within the given ministerial regulations. Their models relate to all subjects and fields at the schools and are typically less specific. On the other hand, even more specific models like "Stepwise improvement" (Caspersen et al, 2016) for programming in ICT-subjects at the high school level are fully integrated into the guiding regulations (Ministry of Education). Other didactic approaches to course design with digital production exist in the regulations, but are limited to the different educational levels, such as the new "Technological understanding subject"[4] in primary education. Literacy and more specifically, digital literacy, is addressed broadly and accepted in the educational sector, among other researchers by O. Sejer Iversen, and Geer Hammershøj, and also by the Ministry of Education. But none of these approaches are interlinked directly and operationally with the other dimensions as it is the case in ROBOdidactic.

The teachers in the projects exchanged experiences regularly during ´network meetings´ in the projects (in average 1 network meeting pr. semester pr. project). Their practice has shown that benefits of ROBOdidactic typically appear when teachers use the model for the following purposes:

a) *Supporting teachers´ communication about learning processes[5] when co-creating courses across different educational levels, such as between vocational high school and upper primary school: terms, focus areas, methods, technologies etc.*
b) *Reflecting on realized courses and conclusions to be undertaken, such as on improvements, repetitions, extensions, upscaling or application of new technologies.*
c) *Planning new courses and considering, what to focus on and which of the elements of ROBOdidactic to emphasize.*
d) *Documentation in public contexts, such as at the projects´ websites, in articles, in presentations etc.*

The model seems to have a unique mission in integrating specific digital production into student-centered teaching, focusing on digital literacy and at the same time opening out to the environment - all of this with an operational and practical approach to implementation.

Promoting digital literacy and "open schools"[6] are policy topics in Denmark. Project owner for ROBOlearning, headmaster Søren J. Rasmussen, Svendborg Erhvervsskole & Gymnasier (Svendborg Vocational college and High Schools): *"Working with digital literacy and integrating the cooperation with companies into daily technological teaching increase our efficiency and offer advantages regarding our college´s promotion."*

The journey

The development process of ROBOdidactic is fully documented. Creation, adjustments and further development of the model have alternated with different kinds of tests and reviews.

From the first considerations in November 2018 until its current version in April 2020, ROBOdidactic 2.0 has evolved, processed and monitored by PhD G. Majgaard, University of Southern Denmark (SDU), Game Development and Learning Technology, and facilitated by project manager R. Lamscheck-Nielsen, Moeve. A wide range of different professional practitioners have contributed, as outlined below more specifically.

A total of 60 teachers and 2,500 of students have been involved in programming courses in crossingIT. In ROBOlearning, approx. 48 teachers have contributed to the process and approx. 1,000 students have been

[4] Teknologiforståelse, new test subject at primary education level
[5] Mandatory in Denmark: "Bridging courses" or thematic subjects, offered to students at level grade 8, 9 or 10, as career learning activities
[6] Schools´ cooperation with companies, cultural institutions, sport clubs etc.

enrolled in courses on robot technologies. In ARducation, so far 38 teachers have related to ROBOdidactic when considering their course design. Something like 1,000 students have participated in learning processes with augmented reality (AR) in relation to ROBOdidactic, and many more courses with AR are planned.

A total of 16 educational institutions represent the primary developing and implementing partners, with 3 of them in several projects. At least 50 other schools, mainly in upper primary education, were actively involved. So far, approx. 5,000 students have learned programming and handling robot technologies or are learning about augmented reality, and the number will be more than doubled by the end of the project ARducation.

The 3 projects were organizationally independent from each other, with different vocational high schools in different cities as the respective project owners. Very few of the students participated in more than one project. But some of the key persons were involved in 2 or 3 of the projects: the project manager, one of the researchers, some of the local managers and a few of the "practitioners of expertise". The same sponsor supported the 3 projects, aiming to increase the Southern Danish youths´ STEM[7] competences and to direct more of the young people towards ICT career pathways.

The project periods overlapped in part, and transfer of knowledge between some of the practitioners and managers could be arranged. Thus, it was possible to achieve a certain level of continuity in the work, to maintain an overview of the entire process, and access to data collection was ensured. New impulses could arise and be acted upon.

The journey has not yet come to its end, but milestones have been reached. The activities in the 3 projects and their results from Nov. 2018 – Oct. 2020 can be summarized as the following 8 phases (table 1):

Steps, projects	1) ROBOlearning: **Development of draft** 11/2018 – 03/2019	2) crossingIT: **Test** 03/2019 – 05/2019	3) ROBOlearning: **Tests** 05/2019 – 09/2019	4) ROBOlearning: **Adjustments** 06/2019 – 10/2020
Activities	Desk research and collection of practice-based experiences. Co-creation of draft in 3 workshops with researcher, facilitator, 8 "practitioners of expertise"*. Reviews of draft at network meetings with broad participation of teachers and managers.	ROBOdidactic for sorting out different types of courses with programming. Researcher´s quality assessment of the courses.	ROBOdidactic for researcher´s assessment and teachers´ self-evaluations of their courses with robot technologies; undertaken in network meetings with broad participation of teachers and managers.	Researcher´s conclusions on interim results of practitioners´ contributions, related to ROBOdidactic.
Results	ROBOdidactic 1.4	ROBOdidactic 1.4 Evaluation report[8] Brochure	Recommendations, revised and new courses with robot technologies	ROBOdidactic 1.4 Presentation at ECEL, article, 2019
Steps, projects	5) ROBOlearning: **Final adjustments** 01/2020 – 03/2020	6) ARducation: **Digitalization to AR-app** 03/2020 – 04/2020	7) ROBOlearning: **Guideline** 05/2020 - 06/2020	8) ARducation: **AR-app** 03/2020 – 04/2020

[7] Science, technology, engineering and mathematics
[8] "crossingIT: Dybdeevaluering Didaktisk perspektivering og undervisererfaringer", Juni 2019

Activities	Revise of ROBOdidactic in a workshop with researcher, facilitator, 8 "practitioners of expertise"*. Written review process for final adjustments and approval by "practitioners of expertise"*.	Transfer of ROBOdidactic to new project with more teachers and other municipalities. Programming of ROBOdidactic into an Android-based app. Research-monitored. Content: Courses with digital production from the projects, animated through AR[9]-elements. 3 reviews in workshops from teachers and managers in ARducation. Adjustments.	Development of guideline in workshop with researcher, facilitator, 8 "practitioners of expertise"*. Written review process for final adjustments and approval by "practitioners of expertise"*.	Programming of ROBOdidactic into an Android-based app. Research-monitored. Content: Guideline integrated. Further development of AR-elements and other media for app.
Results	ROBOdidactic 2.0, published with didactic framework 1.4	ROBOdidactic 2.0 as app with AR-elements, vs. 0.4	Guideline and didactic framework 2.0	ROBOdidactic 2.0 as app with AR-elements, vs. 0.5

**"Practitioners of expertise": Experienced and innovative teachers, managers and educational coordinators with advanced pedagogical insight.*

Table 1: Lamscheck-Nielsen, 2020

The development process, which has lasted 1.5 years so far, will take approx. 1.5 more years, finalizing the current process of virtualizing the model as an AR-app and integrating it broadly into teacher training.

An action research process

Apart from the potentials and limitations of ROBOdidactic itself, the development process can be considered as inspirational, as a documented example of how the creation of a didactic model has been approached.

Researchers from University of Southern Denmark became responsible for the quality assurance of widely different courses with digital production, conducted in widely different educational institutions. Using a generic didactic model that could encompass the diversity of all these courses and achieve a commitment from all participants, would be useful for this challenging task. But this desirable model could not be found, as shown through initial desk research and users´ assessment (Nov. 2018).

A new suitable model needed to be developed. An action research process was designed for this purpose, involving participants from the 3 projects crossingIT, ROBOlearning and ARducation.

Action research as a methodology is broadly applied in social sciences. According to Reason and Bradbury (2006), *"a primary purpose of action research is to produce practical knowledge that is useful to people in the everyday conduct of their lives"*. They continue: *"Action research is about working towards practical outcomes, and also about creating new forms of understanding, since action without reflection and understanding is blind, just as theory without action is meaningless."*

In action research, action phases alternate with reflection phases and support each other. This mission implies that a balance between action and reflection must be created and maintained, to avoid on the one hand *"armchair theorizing"* and on the other hand *"activism"* (Heron et al, 2001). This meant for our process:

- During the reflection phases ROBOdidactic was created and adjusted via input and reviews, delivered by "practitioners of expertise", who were selected as ´experienced and innovative teachers, managers and educational coordinators with advanced pedagogical insight´. A total of 6 didactic workshops and so far, one technological workshop for virtualization/augmentation of the model have been held. In addition, during 5 network meetings in 2 of the projects, feedback from all project participants was collected.

[9] AR: augmented reality; download app freely from Playstore: ROBOdidaktik

- During the action phases, the practitioners developed and implemented courses locally (so far in all 42 selected unique courses so far), collecting experiences, which were evaluated and used during the reflection phases.

Action research processes have different areas of focus, depending on, among other things, the nature of the product to be developed, the professional field and, of course, the size of the project that the action research process is a part of.

Community action research

The development of ROBOdidactic linked several projects to each other, each of them with a certain level of outreach regarding geography and number of produced courses (= new knowledge). Together the 3 projects represent a rather broad collection of empirical knowledge for the promotion of student-centered teaching with digital production. Many practitioners and experts have been involved in the process so far; see section "The journey". The large number of contributors to ROBOdidactic has shown to be an advantage, as the trustworthiness and validity of immaterial project results increase when many competent users have related on them and applied them to their practice.

Together the 3 unaligned projects represent *"large-scale group processes" (*Ann W. Martin, 2001) in the regional education sector. Martin describes the advantages of large-scale group interventions as providing *"the opportunity for a large number of organizational members to understand the need for and develop ideas for change as well as to support and take part in the implementation of change."*

At the same time, the process was also challenged regularly when new project members or organizations joined, or when dedicated users left for different reasons (career changes, diseases, organizational disposals etc.). Knowledge was lost, new attitudes and expertise emerged and had to be taken into consideration.

A suitable action research design seemed to be *"community action research"* (Senge et al, 2001). This design focuses according to the researchers, especially on a) "*fostering relationships and collaboration among diverse organizations, and among the consultants and researchers working with them"*, b) *"creating settings for collective reflection that enable people from different organizations to see themselves in one another"* and c) "*leveraging progress in individual organizations through cross-organizational links […]"*.

As a whole, all involved parties (researchers, project manager, local managers, teachers etc.) can be considered as a *"knowledge-creating system"*. Senge and Scharmer offer a model as a stock-flow diagram of the knowledge-creation system, also including dangers for "breakdowns" (fig. 2).

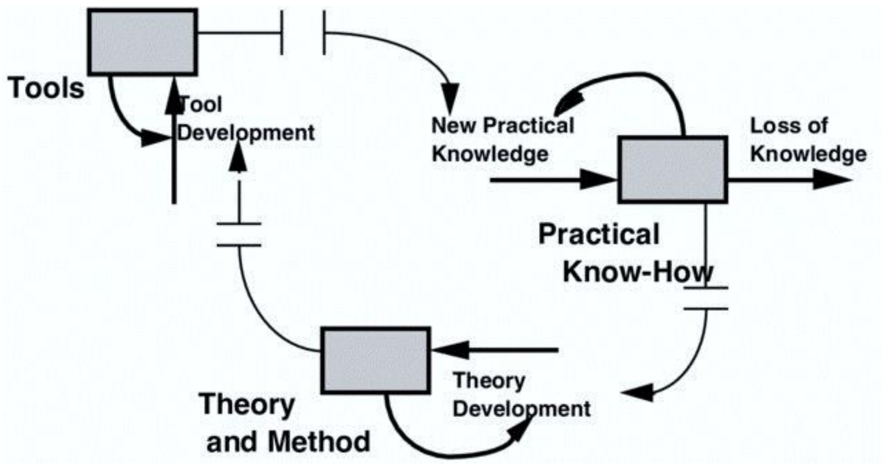

Fig. 2 Scharmer, O. C., MIT Sloan School of Management, Massachusetts Institute of Technology (2001)

The *"tool"* in this case is ROBOdidactic, which was developed by cumulating and adding *"new practical knowledge"* (= results from new courses) and *"practical know-how"* (= teachers´ experiences), recovering from *"knowledge losses"*, including *"theory and method development"* (= research-based literature and new guideline), which again influenced the further development of ROBOdidactic.

The development of ROBOdidactic was undertaken in a kind of iterative process, but not closely tied to the intended model itself. The main focus was on knowledge-creation, and the promotable activities were designed as the next steps to follow up on the learnings that emerged during the development process. Thus, there was a need for an accordingly flexible project design.

An agile, adaptive and participatory project design

The action research process was dependent on a linkage between and integration of the 3 projects. The realization of this naturally implied a supportive project design, as well as backup from the project manager and the 3 project owners.

In the Danish education sector, projects must most often be designed according to given frameworks from the sponsors. It can wonder that many of these frameworks are based on a rationale of predictable and directable learning processes, taking place in a simultaneous pace for all participants, with controllable and measurable impacts by the end of the projects. This rationale contradicts the last decades´ educational research about differentiated learning processes, the official fundamental focus on each individual´s "independence" in the Danish education sector (Ministry of Education, example: goals 2017) and individual study plans in vocational education and training.

Other project concepts seem far more suitable, when working with human development processes and unspecified immaterial final products. All 3 projects were designed with an *agile*, *adaptive* and *participatory* approach.

Agility as a project concept includes (regular, often pre-determined) stops in order to conclude on the product development as achieved so far. This results in conscious learning during a project with the consequence of redesigning product specifications and redirecting or reorganizing deliveries, when barriers, pushbacks or new insights arise.

Agility is often associated with software development projects and iterative processes, as its principles were developed and supported worldwide for this purpose (Agile Manifesto, 2001). Since then, the principles for agility have been transferred to other contexts. Agile project management, also called ´dynamic project management´, has become an important approach to navigate in changeable environments, while at the same time satisfying the customers´ needs (Højgaard et al, 2012). The customers´ needs can actually also change in the course of a project´s work towards a final product, as time goes on.

While agile project management focuses more narrowly on dynamic and appropriate product development, an *adaptive approach* tends to prepare the project for coping with contextual changes. Adaptive project management includes exploring problems and uncertainties, deliberating alternative solutions and reframing problems and solutions (Rijke, 2014). Fladkjær Nielsen et al (2016) have described characteristics for complex projects. They point to *adaptive project management* for projects with unspecific and changeable goals, influenced by political and emergent surroundings, with a high degree of uncertainty or even chaos.

The Danish education sector (and possibly many other sectors, nationally as well as internationally), is to a high degree exposed to influences from the environment, no matter whether the influential circumstances are expectable or unforeseen: education policy decisions and decrees, demography, changes in youth culture, parents´ attitudes, requirements from the industries and many other things. Lately, the problems and restrictions related to COVID-19 have had a great impact on everyone in the sector.

All 3 projects met several major contextual problems, of which each of them could have harmed the respective project dramatically.

- crossingIT experienced a partner drop-out because of a serious staff reduction. The project management and the project owner of crossingIT hurried to find a new partner and, at the same time, could convince the existing partner to keep a minor share in crossingIT. Thus, the expertise was not fully lost, and expansion could even be achieved.
- ROBOlearning never did succeed fully regarding its ambition of creating a partnership with the local robot trade. Instead, the local municipality became involved with labor market consultants who could contribute important contacts to managers and engineers in robot companies.
- Both ARducation and ROBOlearning were hit heavily by the COVID-19 crisis. ROBOlearning managed to reorganize its robot event with the anticipated 1,000 students several times, landing on a solution with a series of minor events. ARducation transformed all personal meetings to virtual meetings and bilateral collaborations. The locked-down periods were used introvertly for AR-app production.

The *participatory approach* plays an important role in the education sector, also internationally (European Political Strategy Centre, 2017). The model ROBOdidactic itself follows this principle by placing the students in the center and by highlighting “the students´ co-influence” on teaching design.

The direct users of the model – teachers, managers and educational coordinators – had a decisive influence on the interim and final model. The researcher, project manager and project owners were fully loyal to the practitioners´ contributions, assessments and review results. Professional curiosity (Mehlsen, 2020) and mutual respect for each other´s findings were crucial.

The mission for the 3 projects was not only to produce new courses and a new tech-didactic model, but also to result in local changes. The project owners as well as the managers of their partner organizations wanted to further develop their local learning environments and strengthen not only the teachers´ tech-didactic competences, but also their mind-sets for digitalization. This implied a higher degree of knowledge-sharing among the teachers and between the schools, as well as an increased openness to implementing new technologies. These outputs would not be achieved using more instrumental project approaches, which are more suitable for creating ´behavior control´ and standardization of work processes (Simonsen et al, 2016).

The participatory approach promotes personal commitment from the project members. It was realized in the projects by, among other things, involving the practitioners into co-design of the workshops and network meetings (see section “The journey”), allocating decisive responsibilities to them and highlighting their performances publicly. The project owners and local managers formed steering groups, where all important decisions were taken. Relativizing the outcome, commitment definitely has not been achieved from all project participants. The number and diversity of the participants and the organizations involved was simply too high. And when one of the colleges decided to concentrate on their own business, this was accepted by the respective steering group.

Finally, it must be emphasized that management of the 3 projects also involved navigating between the different stakeholders and combining their interests: a) the users interested in efficient courses with a high learning impact on their students, b) the researchers targeting a valid didactic model for quality assurance and c) the sponsors´ requirements regarding documentation and expectations of an impact on students´ competences and career choices in the region of Southern Denmark. In overcoming opposing interests, a crucial key to managing the entire process was identifying synergies between the 3 projects and between the different interests.

Conclusions

The outlined overview of the model ROBOdidactic and its journey undertaken in the frameworks of 3 Danish projects, offers answers to the initially asked questions.

ROBOdidactic is a practice-based and practice-directed tech-didactic model for designing courses with digital production. The non-normative model offers inspiration and methods for planning and evaluating tech-courses within 4 dimensions: teaching design, digital production, digital literacy and the environment for the courses. Its 21 elements are outlined concretely in guidelines and can be selected in a didactic framework. The model is in its early use in secondary education and in transition courses between upper primary to secondary education.

“Practitioners of expertise” from several educational levels, subjects and school types have co-created the model, assuring a common understanding of teaching with digital production. The terminology that was agreed upon by the teachers and other experts, eases a broader communication regarding their courses.

ROBOdidactic is the result of an agile process, undertaken as community action research in an adaptive and participatory project design. Three mutually independent projects with different timelines were used for this purpose. At the same time, synergies between the projects were achieved.

So far, the complex challenge has been met. But other tasks are waiting. All stakeholders must have satisfying outcomes, including, more broadly, the education sector as well as the technological sector in general. The journey with its tasks has not yet come to an end.

New perspectives

The next steps to take are directed towards the finalization of ROBOdidactic as an AR-app, including the first documented AR-experiences in teaching. Teachers will experience the app in teacher training, while they will plan courses with digital production, among other things with augmented reality (AR).

International interest is increasing, and experts from several countries are considering a joint cross-national project, with ROBOdidactic as a common framework for communication. Placing ROBOdidactic in an international context, with other countries´ practices for teaching designs and their preferred theoretical models, will naturally challenge the ROBOdidactic, and new insights are sure to emerge.

Finally, ROBOdidactic may need to be further developed, when yet unknown emerging technologies challenge teaching design as we know it today.

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- and https://www.robo-sydfyn.dk/robodidaktik/

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