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# Augmented Reality in Vocational Education

## POVZETEK

Povzetek

KLJUČNE BESEDE: ključne besede

## ABSTRACT

Abstract

KEY WORDS: Digitalization, emerging technologies, Augmented Reality, Playground approach, individualized learning, differentiation, Digital Literacy, implementation

## Abstract

The paper “Augmented Reality in Vocational Education” offers a study of how to approach implementing Augmented Reality (AR), as one of the emerging technologies these years, in Danish Vocational Education and Training (VET). An ongoing alignment with innovative trends and upcoming technologies in the trades is vital for vocational colleges in the Danish dual VET system. At best, new technologies contribute pedagogically, promote individualized learning, and bring professional inspiration for students and companies.

The paper reflects on the results of a case study about the course “Augmented SWOT-analysis”, conducted in initial VET at the Danish Business College Vestfyn. This course is one of many local solutions for applying AR to teaching and learning processes, with thus far more than 7,000 students enrolled. All together the courses represent different levels and degrees of complexity. In most courses, the students have produced AR elements or apps themselves as their learning products. As a minimum, the students have learnt to use ready-made AR-apps with relevance for their studies.

To discuss the challenge of a longsighted and sustainable implementation of emerging technologies, the tech-didactic model ROBOdidactics is highlighted as a framework to make teaching with digital production communicable, transparent, and transferable. But in addition, course documentation and teachers´ exchange must be facilitated, as well as promoted by the pedagogical school management. The backbone for implementation processes consists of continuity and strategical focus.

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## (1) Introduction: Context and background in Denmark

Denmark is one of the most digitalized countries in Europe (DESI 2020), and national policies with digitalization strategies are in full operation in the educational sector as well (Danish Ministry of Education, 2017).

Danish initial Vocational Education and Training (IVET) is a genuine dual system with strong historical roots, based on political traditions (Koudahl 2007). The students spend ~ 70 % of the programs in apprenticeships, conducted and salaried in training companies. Thus, the trades are crucial stakeholders and have decisive influence via their "trade committees" (ibid). The driving forces for didactical and pedagogical innovation in this dual system are the VET colleges.

Due to the structure of Danish VET, inspiration of new technologies and trends comes first and foremost from the industrial sector, from business and administration, the social & health field, as well as the farming & food sector. As a highly competitive economy, the Danish trades must have a strong and consistent focus on emerging technologies for continuously increasing effectiveness, improving quality, and creating innovation. These days, there is a high focus on Virtual Reality and Augmented Reality, on new robotics for automation, chat bots for service processes, on programming broadly and on many levels, on inventions for the game industry, collaborative virtual spaces, artificial intelligence, as well as on 3D printing in many variations.

The VET policies and ordinances for the educational programs include the demand for new technologies. Among other supportive initiatives, 7 publicly funded knowledge centres for technological expertise are available for the different professional directions in VET. The VET colleges themselves are engaged with local development according to their own digitalization strategies and join local or regional innovation projects to promote the processes.

The crucial principles are, on the one hand, to prepare the students for the labour market and, on the other hand, to provide the students with technological insight and digital literacy they can bring into businesses and thus contribute to commercial development.

Student access to VET is chronically too low, compared to the immense and urgent need for skilled workers in Denmark. Approx. 20 % of a youth cohort enter VET, equivalent to 28,881 students in 2019 (Ministry of Education, 2021). In 2018, in total 107,100 students were subscribed to a VET programme, with an average age of 23.9 years (Danmarks Statistik, 2019).

The characteristic that probably is most common for VET students is their preference for a practical and result-oriented approach to learning. Apart from that, the students differ widely, regarding age, cognitive and physical skills, socio-economic and cultural background, ambitions and goals (Størner, ed., 2014). The diverse population includes students who enter VET with massive basic learning problems and, in some cases, complex personal challenges, even though access to VET has become conditioned to a having certain maturity and passed exams in Danish and mathematics (2014, VET reform). The number and dispersal of students with learning problems differ from VET programme to VET programme and class to class.

The Danish VET system tries to meet this diversity and its challenges with a high degree of flexibility, which is outlined in the VET law and the ordinances. The programs take place on several levels at the same time, and the students each follow their own individual study plan. It is a continuous and challenging condition for VET managers and teachers to differentiate and meet the students´ needs, learning preferences, and goals in individualized learning processes.

## (2) Research question and methodology

The implementation of new technologies in VET must be seen in the multi-spectral light, as outlined above. This context has fostered quite an extensive activism in the entire Danish VET system, regarding a continuous identification and exploration of emerging technologies to integrate into teaching and training. The study reflects on the following research questions:

a) When implementing emerging technologies: how to approach the pedagogical process in daily vocational teaching practice in vocational education?
b) Why is the implementation of emerging technologies both a challenge and an opportunity in Danish vocational education, and what to consider in this process?

### a. Methodology

To meet the first research question, a case study (Yin 2014) was chosen to deliver data for in-depth considerations about pedagogical obstacles and opportunities. The case study took place from April to September 2021 in the framework of the Southern Danish innovation project "ARducation" (2019-2022) and complements its strong quantitative focus.

The second research question is considered with respect to insight from 3 Danish innovation projects for the implementation of emerging technologies. These projects were didactically connected via referring to the model ROBOdidactics (Majgaard, 2019). We look at possible perspectives through this tech-didactical model.

## (3) Innovation projects with emerging technologies

This study relates to the implementation of emerging technologies in a portfolio of 3 mutually independent projects, with the Southern Danish Region as their public sponsor:

*crossingIT* (2017-2019), implementing programming in teaching and learning processes,

*ROBOlearning* (2018-2021), implementing robot technologies in and across subjects,

*ARducation* (2019-2022), exploring and implementing Augmented Reality in commercial and technical vocational programs (note: not yet finished).

The courses took place in initial VET and in upper secondary education (year 10-12), as well as in the transition from lower secondary education at year 8-10 up to VET/high schools. The courses came in many variations:

- Learning units integrated into ICT-subjects, typically 10-20 hours
- Weekly lessons, integrated into longer-lasting courses over ½ - 1 year
- Extensive project work blocks of 20-30 hours, typically as multi-disciplinary courses
- Modules of 1.5 - 4 hours´ duration, for pupils from lower secondary school
- Learning units across levels, joined by students and teachers from different educational programs or types; as short modules, blocks of 10-20 hours or events
- Courses with mandatory exams, as voluntary subjects, or leisure time courses

85 unique courses have thus far been conducted locally (Oct. 2021), many of them with several iterations and numerous repetitions.

### b. Spotlight on courses with Augmented Reality (AR)

In the project "ARducation" (Sept. 2019 - June 2022), teachers from 3 VET colleges and researchers from the University of Southern Denmark (SDU) explore Augmented Reality (AR) for its applicability in VET. AR, belonging to the Mixed Reality technologies, adds a virtual layer to physical reality. Thus, AR offers supplementing illustration or information that can give insight into normally hidden processes or create phantasy elements extending reality.

Approx. 7,000 students have thus far been enrolled in courses with AR (Oct. 2021). The courses carried out have taken place as 10 unique variations at the VET colleges and as 6 unique variations at years 8-10. In addition, most of the variations have been conducted several times, either as repetitions or as further developed iterations.

AR is applied in different ways. AR as a technology is typically treated in ICT-subjects with a focus on programming processes and graphic design (ARducation, Business College Vestfyn, 2021). Multi-disciplinary courses integrate AR typically for the goals of learning projects, such as exploring "How can AR solve daily life problems" (ARducation, Business College South, 2021). Finally, the potential of AR in teaching materials is investigated (Vocational College Svendborg, 2020), and AR for supporting learning processes (Business College Vestfyn, 2021). All together the courses represent different levels and degrees of complexity. In most courses, the students have produced AR elements or apps themselves as their learning products. As a minimum, the students learn to use ready-made AR-apps with relevance for their studies. In all cases, the work with the technology relates to the mandatory learning outcomes for the subjects.

## (4) Pedagogical lenses

The following 3 approaches will be related to the case study, section (5).

### a. Individualized learning

Individualized learning is a fundamental condition in Danish VET with one of the crucial goals that the VET programmes *"must challenge all students so they may reach their fullest potential"* (Ministry of Education, reform 2014). This approach is to be met organizationally, didactically, and pedagogically (Lamscheck-Nielsen, 2020b).

The Danish VET programs take place on several levels at the same time. Individual study plans for all students have been compulsory for more than two decades now. In daily teaching practice, an appreciative approach is fundamental, when the teachers incorporate the students´ individual needs, their personal motivation and goals, their learning preferences, and their topical levels in the subjects. Differentiation is required according to the students´ learning styles and their individual relevance of learning matters. Framing the students´ co-design of teaching is another important mission. Feedback, feedforward, and peer reviews are crucial steps during formative evaluation processes. (Quality MAP, 2014).

At the same time, group processes play an important role in learning processes. This aspect is still underexposed in the individualized learning approach. But there is a growing awareness of psycho-social well-being, group dynamics, communities, and inclusive learning environments.

### b. Playground approach

A recent transfer of playground methods from primary education to youth education level has brought new perspectives and methods to the secondary education level (Christiansen, 2020).

In the playground approach, exploration, creativity, and fun are learning drivers, which notably raise the energy level in a class. There not saying that there is no methodology to apply consciously. There are different methods for different purposes, such as for initiating a process, for generating ideas, for making decisions, for trial-and-error, for communicating results, or for promoting and challenging group dynamics (project ROBOlearning, workshops 2019-2020).

The approach implies working with the individuals´ comfort zones, which naturally differ. Especially in IVET, which is characterized by the students´ broad age span and heterogeneity, different reactions or even resistance and unintended fall-backs may arise.

A common denominator is often a physical aspect in the methods, by involving artefacts or making the students be physically active. Thus, the playing persons will possibly use parts of their body or outfit, change seats, explore things, the room, or its features.

All in all, timing is essential, making the students and classes familiar with the playground approach: The right method for the right purpose at the right time for the right target group.

### c. Digital literacy

The extensive digitalization in professional and private life has brought the need for basic knowledge and competencies regarding advanced technologies for everybody: ´digital literacy´.

In the context of youth education and with reference to the model ROBOdidactics (…….), digital literacy covers a fundamental technological empowerment of students, their critical thinking and ethical considerations regarding their own and others´ us of digital technologies and media.

In this context, the learners´ ability to relate technologies and themselves to others and to different contexts in a well-reflected way is promoted. Students learn to produce in communities-of-practice, being aware of their roles and contributions. Their analytical “computational thinking” in planning and programming must be trained to finally achieve sound technological actionability.

Digital literacy cannot stand alone, but it is dependent on modern “common literacy” that arms us for our citizenship and let us take responsibility for ourselves, for each other, and for the development in our society (Hammershøj, 2017).

## (5) Augmented Reality in initial business education – a case study

In the case course “Augmented SWOT analysis”, AR was used for the support of learning processes in IVET. SWOT is a classical business tool for strategic planning processes, which typically causes difficulties for the students. Thus, it should be investigated whether/how AR could promote students´ learning of a given theoretical theme or subject. Other courses and purposes could have been the object of this case study. Practical circumstances such as logistics, availability and timing made us prioritize this course. It might be considered whether and how future studies of other courses can qualify the conclusions of this case study.

According to Yin, a case study can bring insight into qualitative processes, but rarely cover all aspects (2014, p. 9-10). We decided on using the selected pedagogical approaches (section 4) as lenses for the case study, mainly because they are generally relevant in Danish VET and because teachers can use them to operationalize the findings. In addition, these approaches can illustrate and further qualify the work with the didactic model ROBOdidactics (2020).

### a. The case course "Augmented SWOT-analysis"

The course "Augmented SWOT-analysis" at Business College Vestfyn has thus far been conducted with 2 iterations (April and Sept. 2021), and more are planned. The course is freely available, as described in detail according to the ROBOdidactics framework.

Both iterations were integrated into a longer-lasting vocational subject, and their number of participants was low due to Corona restrictions. The iterations contained the same 4 steps:

1. *Approx. 20 %* - The teacher´s introduction to the commercial use of AR-apps by presenting AR live and relating to the students´ daily lives (online shopping of shoes, PR of furniture).
2. *Approx. 15 %* - The teacher´s instruction into the learning task: a) Create your own AR-reader manually from a paper version (technology: MergeCube), b) Explore the business model "SWOT Analysis" by using its augmented version (accessing technology: CoSpaces), c) Relate the SWOT-model to your training company, d) Create a draft for implementation of AR in your training company (a mock-up, outlined as a cube).
3. *Approx. 60 %* - The students´ pairwise exploration, using their own smartphones, and solution of the learning task, with individual fill-in of exercise sheets.
4. *Approx. 5 %* - Evaluations by the students and the teacher.

*Iteration #1* was a module of 3 hours, conducted as a morning lesson with 9 students aged 17–52 years, on IVET level and high school level. The students had followed their programme for almost 2 semesters with no obvious major learning difficulties, though a few of them had overcome personal obstacles. The students had learnt about SWOT in a previous theory lesson.

*Iteration #2* lasted 80 min., conducted on a Friday afternoon. The 7 students (16-18 years) had recently entered VET, following the basic IVET program. 4 of them had clear learning difficulties for different reasons. None of the students had previous knowledge about SWOT.

### b. Results

The results from both iterations relate to a) the students´ visible learning results, b) observations and video-recordings undertaken by an external consultant and c) reflections from the teacher.

*a) The students´ learning results:* All students succeeded in constructing their MergeCubes and exploring the SWOT model virtually. In iteration #2, the students with learning difficulties struggled when constructing their analogue MergeCubes, but managed fine when using their smartphones and entering AR. All students in iteration #1 and the 3 stronger students in iteration #2 explored and discussed the SWOT concept via its augmented version.

The students in iteration #1 had time enough to elaborate realistic and practicable suggestions for implementing AR in their training companies. Some of the students ended with mock-ups of AR elements for PR purposes in business. The quality of the learning products documented the students´ new professional insight in applying SWOT and AR for business purposes. In addition to the lack of time for this task in iteration #2, 2 students stated with regret not yet having achieved a training placement.

*b) Observations and video recordings:* In both iterations, the students showed an extraordinarily high interest, when it came to AR. Initially the students listened surprised and amused, when the teacher introduced the AR-apps live, testing them at the students´ outfits. Especially when applying AR themselves, the excitement rose in the classes. The students used their selfconstructed MergeCubes and their own smartphones and moved around following the AR elements. Some students took additional notes and referred to other learning materials.

Video recordings of students (average level, iteration #1) documented their creativity and motivation for applying innovative technologies in a practical and meaningful way in vocational practice. Young woman, 19 years old: *"This is really fun. We should apply this much more also in other subjects, and the teachers should let us make our deliveries with AR!"* Literally, all students from both iterations expressed a preference for AR, compared to traditional learning materials: *"Everything is better than books"* (girl, 17 years old, iteration #2).

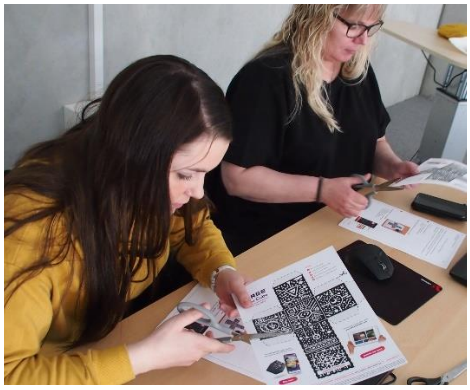
The group processes in pairs were unfacilitated. In most pairs, the students interacted closely; they supplemented and helped each other, built on each other´s inventions and findings. In 2 pairs, the students worked individually without listening to or including each other´s input.

Finally, while the students of iteration #1 continued their work also during the break and after the module, the students of iteration #2 left the class immediately after the end of the module to start the weekend: *"It´s been a long week"*, as one of them said.

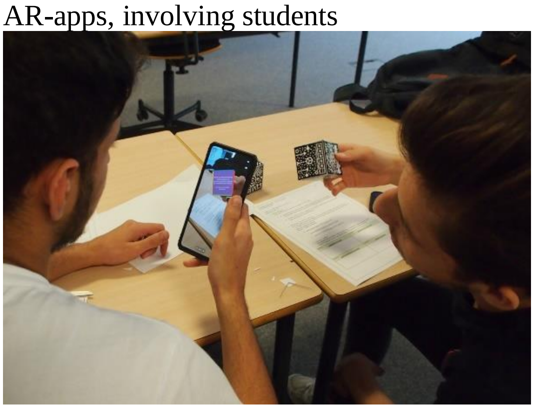
c) *The teacher reflected* on the positive impact of AR on the students: *"They grasped AR intuitively, they are highly motivated. Many could transfer it to business."* and *"AR matches the students´ practical way of thinking and learning - they like action."* At the same time, she became clearly aware of the 4 students´ difficulties (iteration #2): *"They normally can hide this or would leave"*. Reflecting on the behaviour in some of the groups, she gestured and stated: *"It is visible when they do not really cooperate and just sit together working alone."*

### c. Illustrations

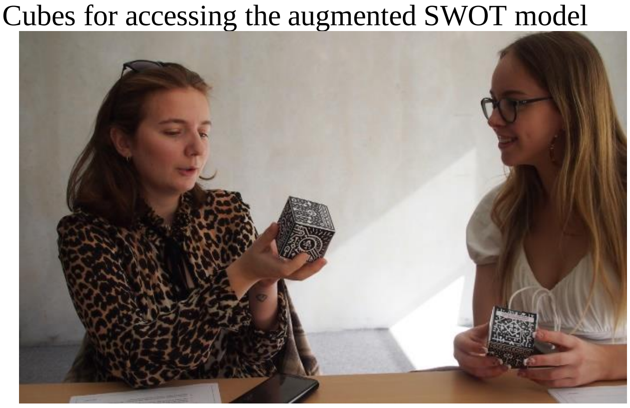
Ill. 1: Teacher´s introduction to commercial AR-apps, involving students



Ill. 2: Students´ individual constructions of Merge-Cubes for accessing the augmented SWOT model



Ill. 3: Students´ working together in pairs, exploring the augmented SWOT model



Ill. 4: Students´ SWOT-analysis and transfer of AR to business purposes in their training companies (video)

### d. Analysis

*Individualized learning* seemed to have been both supported and challenged.

The students were prompted to relate AR to their personal lives as well as to their training companies. In addition, many students came up with ideas on new AR-business fields or related to AR in widely different areas. Thus, the technology showed to become relevant for all of them. Individual solutions were elaborated, qualified in pairs.

Nevertheless, the individual approach was challenged, too, such as when it became transparent that some students could not live up to average expectations and norms in vocational education.

With the teacher´s considerations in mind, group processes had not been sufficiently scaffolded for unfolding their full potential. Playground methods could have been used for this purpose, and for some students, detailed instructions should possibly have been applied.

Roughly said, all students showed and expressed their attraction to a tactile consumption of theory. Thus, it was found that the application of AR can meet preferences for certain learning styles, especially in VET where students typically have a more practical approach to learning.

*The playground approach* as a framework for considerations about the application of AR offers explanations and may cause changes in teaching design.

AR clearly triggered the students´ curiosity and motivated them to explore a difficult theoretical business model. Though, it could not be stated whether the high interest was caused by AR itself and will have a lasting impact or whether it was due to the novelty of the media. Partly, the motivation seemed to be rooted in an aversion against traditional scholastic ways to achieve theoretical knowledge. Nevertheless, playful methods seemed have made a difference.

The timing of bringing in new technology is important: When to apply AR – before or after having gone through the theory or simultaneously? How long does it take to relate to AR as a new media in a theoretical subject? When, during a tight weekly schedule, to introduce to new matters? When and how during a vocational programme can independent group work occur?

*Digital literacy* must be promoted and go hand in hand with common literacy.

While AR made a positive motivating difference for the stronger students when exploring and applying SWOT, the students with learning difficulties were not able to approach and use new technology and simultaneously apply it as a learning material for accessing new theoretical knowledge.

Digital literacy, with its technically empowering aspects and with its ethical considerations about new digital technologies, is highly relevant for all students. But, in addition, some students need support for achieving a higher degree of common literacy, such as how to structure learning processes in general, how to meet and collaborate with others, how to relate to deadlines or how to reflect on their own performance and career learning. The need for knowledge about Danish society and cultural signals plays a part here, as well.

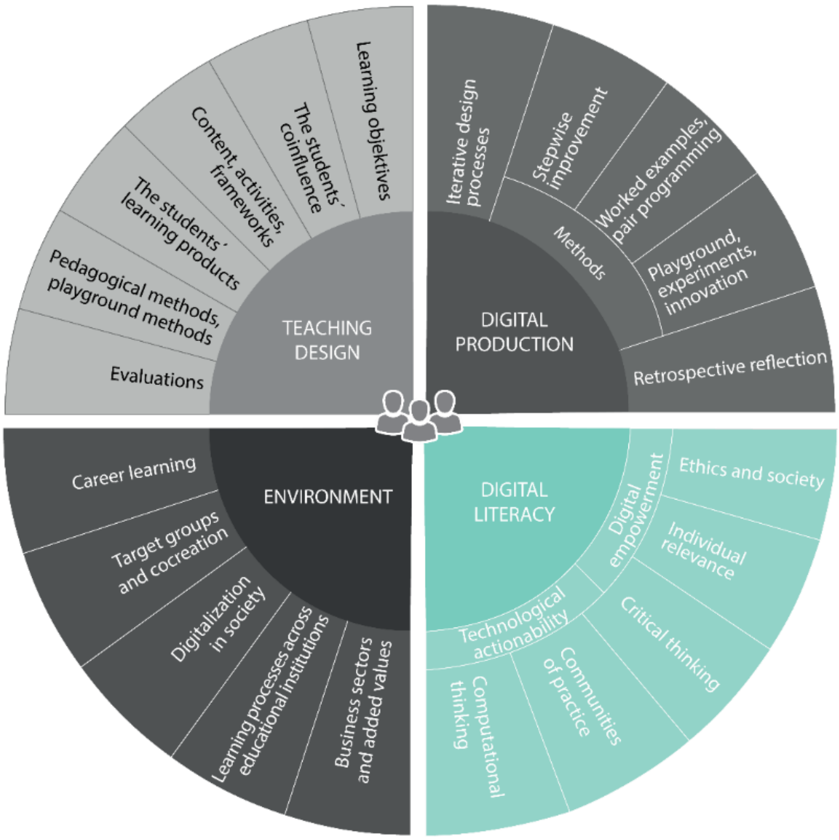
## (6) Implementation processes & ROBOdidactics

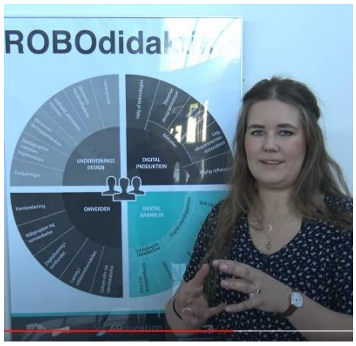
Implementation processes have also a long-sighted aspect, which comes up regularly as a kind of never-ending topic when speaking about pedagogical development and school development in general.

The nature of Danish VET as a dual system, with students performing in commercial practice most of the time in their programmes, requires the VET colleges´ ongoing alignment with innovative trends in the trades, among them emerging technologies. This is a challenge for teachers per se, as they have to find time and possibilities for testing and implementing new technologies, technically and didactically, as a continuous process, but often also rapidly.

At the same time and in general, VET teachers practise flexibility due to the individualized approach and the frequent interaction with local training companies. New technologies can contribute to differentiation, to create motivation, and to inspire both students and companies.

The non-normative model ROBOdidactics (Majgaard, 2019) supports course design with digital production. Though allowing localization of course design, the model offers a systematic way to test and implement new technologies in teaching practice, as it has proven to make teaching processes communicable, transparent, and transferable (Lamscheck-Nielsen, 2021).



Ill. 6: Teacher´s reflections on her course design according to ROBOdidactics (Case study, Vocational College Vestfyn, Apr. 2021)

Ill. 5: ROBOdidactics (as a language translation of ROBOdidaktik vs. 2.0, Denmark, 2020), developed during a community action research process 2017-2022 (Lamscheck-Nielsen, 2021)

Experiences from the project ARducation and related projects show that freely accessible course documentation and personal exchange among teachers increase the teachers´ courage, competencies, quantity and quality of their courses with emerging technologies. However, these processes must be framed, as explained by Majgaard (2021, evaluation ROBOlearning):

*"Further tech-didactical development requires a setting. This can be a project, a teacher network or a dedicated group, specific tasks with reflection on own practice, teacher training or other settings, but in all cases to be promoted by the pedagogical school management."*

Thus, catching emerging technologies and implementing them broadly at a VET college require outlook and enthusiasm for a novelty, but even more, it requires continuity and strategical focus.

## (7) Conclusions and perspective

This study has led to conclusions about how to approach the implementation of Augmented Reality, as one of the emerging technologies these years, in Vocational Education and Training.

*A pedagogical process in depth*

Pedagogical processes depend on many factors and should be investigated in a broad variety. This paper has reflected on the results of a narrow case study about the course “Augmented SWOT-analysis”, conducted in initial VET at the Danish Business College Vestfyn. The students´ learning results, an external consultant´s observations, video recordings and the teacher´s reflections delivered data from 2 iterations of the course in 2021. The data were analysed via 3 approaches: Individualized learning, Playground approach, and Digital Literacy.

Overall, AR was found to have the potential as a supportive technology for stimulating learning of professional topics in a subject. This was indicated by the high motivation of the students, the quality and innovative value of their learning products, their active involvement in the learning processes, their reflections on the commercial use of AR, and their suggestions for adding AR broadly to their VET programme.

AR can support *individualized learning*, as the technology can promote differentiation such as through personalized themes, levels, and style. AR naturally offers a visual and tactile alternative to more traditional learning materials and seems to appeal to the more practically oriented students in VET. The *Playground approach* can provide inspiration for method choices. Introducing emerging technologies triggers the students´ *Digital Literacy* when increasing their skills for accessing new technologies, reflecting on ethics, and identifying personal relevance. It can, though, be a challenge for some students that this process requires a more general literacy with a certain self-awareness and knowledge of society, its values, and rules.

In addition, some points need attention. Group processes for digital work need scaffolding according to the purpose of these communities-of-practice. Timing of AR modules seem to be critical, in terms of duration, placement in a week schedule, and thematically during a VET programme. Finally, pairing the complexity of theoretical learning content with offering a brand-new technology should be well-considered, depending on the individual students´ capacities.

*A long-sighted perspective*

Implementation of emerging technologies means challenges and opportunities for Danish VET. An ongoing alignment with innovative trends and upcoming technologies in the trades is vital for colleges in the dual VET system. At best, new technologies can contribute pedagogically, promote individualized learning, and bring professional inspiration for students and companies.

All aspects to consider for implementation processes would have extended this paper by far. But the attention is led to the tech-didactic model ROBOdidactics (Majgaard, 2019). ROBOdidactics offers a framework to make teaching with digital production communicable, transparent, and transferable. However, broad implementation processes with course documentation and teachers´ exchange must be facilitated in settings such as networks, projects, training, or others, and all cases promoted by the pedagogical school management. Continuity and strategical focus are the inevitable backbones in this long-sighted work.

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