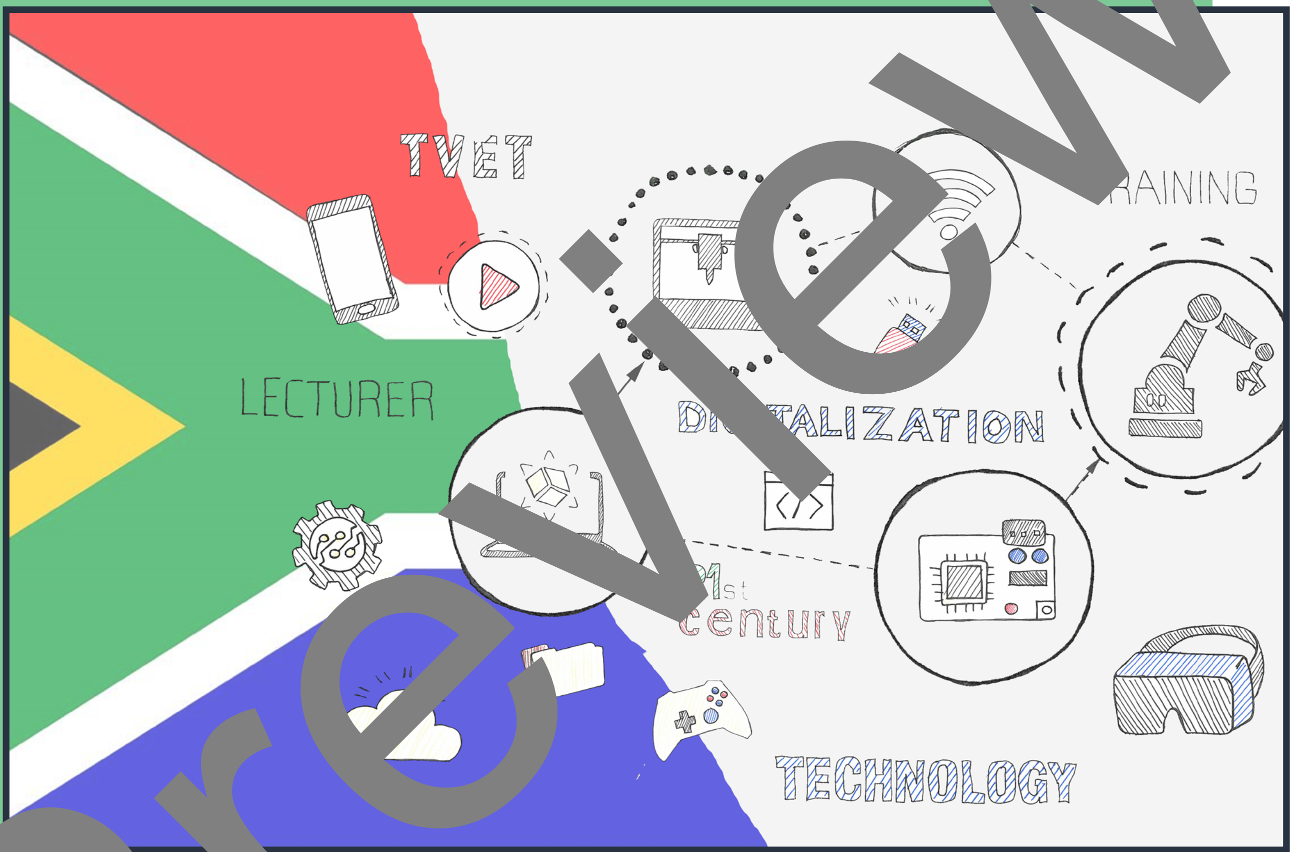
STUTTGART 2023

MODULE I.1

DIGITAL TEACHING AND LEARNING IN TVET

Course Book



TRAINME 2 - ADVANCED MODULAR TRAINING & EDUCATION

IN MECHANICAL & ELECTRICAL ENGINEERING

Education is Future

TRAINME2

1^ST^ EDITION

EDITING

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This course book has been developed within the bilateral programme TRAINME 2 in order to promote in-service lecturers' Technological Pedagogical Content Knowledge (TPACK). The programme has been designed by the Inter-Company Training Center in Eastern Bavaria (ÜBZO) and University of Stuttgart, Department of Vocational Education focused on Teaching Technology (BPT) on behalf of the German Federal Ministry of Education and Research and DLR in cooperation with the South African Department of Higher Education (DHET).

Stuttgart, September 2023

TRAINME 2 – Modular training and further education of South African TVET-lecturers in mechanical and electrical engineering

Powered by: ÜBZO Überbetriebliches Bildungszentrum in Ostbayern gemeinnützige GmbH; University of Stuttgart Germany; higher education & training, Department: Higher Education and Training, REPUBLIC OF SOUTH AFRICA

Supported by: Bundesministerium für Bildung und Forschung; DLR

CONTENT

LIST OF FIGURES

LIST OF TABLES

DEAR TEACHERS & LECTURERS,

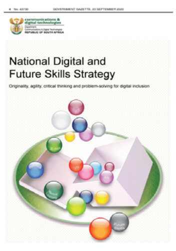
even if many uncertainties remain about how the digital transformation will affect economy and society globally, it is for sure that a relevant set of knowledge, skills and attitudes – called digital competences (Ferrari 2019) – has become vital to study, work and participate in society and culture in the 21st century (OECD 2016; Stromquist 2019).

In the case of South Africa, skills intensity has already increased in most major sectors in the post-apartheid era (World Bank Group 2018). Standard technologies (cf. Mishra & Koehler 2006) such as email or messengers for communication, video conferencing applications, the internet or computer hard - and softw[illegible] already pervasive in the workplace (Twinormurinzi 2020). In addition, there is a growing need for specific or advanced technology (Guthrie et al. [illegible]) that d[illegible]cts to Industry 4.0 such as AI, robotics or 3D technologies used specifical[illegible] in a certain profession. Especially the mining, manufactu[illegible] [illegible]vices sect[illegible] are going through significant transformation by a range of advanced technologies (DCDT 2020).

Against this background, South Africa's government [illegible]entified digital-related skills as the key to increasing job creation opportunities. [illegible]tional Digital and Future Skills Strategy, the South African government published eight main interconnected elements for the development of a digital society. Aligned with the most recent definitions of digital inclusion (Djukic 2022) and digital competence (EU 2018), the strategy aims to [illegible]ility of South Africa's citizens to approach and use digital technologies. This refers to [illegible]s and usage of information, media and data literac[illegible] [illegible]ation and collaboration, digital content creation, safety, devices and software operations and problem solving. It is necessary in order to [illegible] prepa[illegible] both careers in the field of learning, [illegible] worki[illegible] world and so[illegible] of the 21st century (DCDT [illegible]).

DIGITAL SOCIETY SOUTH AFRICA: South Africa's National e-Strategy towards a thriving and inclusive digital future

[illegible]ed on the c[illegible]ing South African [illegible]ork landscape of South Africa and the country's vision of an inclusive digital society, one of the eight elements is the development and promotion of educational systems – in particular TVET – that must respond to desirable competence development for the 21st century working world, society and culture (DCDT 2020; Makgato 2019; Naudé 2017).



National Digital and Future Skills Strategy: Originality, agility, critical thinking and problem -solving for digital inclusion

PREAMBLE

The integration of digital technologies modifies the entire didactic-methodological setting of a lesson – both in face-to-face lessons and in distance learning. Digital technologies influence perception and cognition, they cause a change in teaching-learning activities and can therefore not be regarded as an isolated decision for a time-limited stage of teaching. Planning the use of digital technologies includes the selection of digital technologies for its lesson preparation, teaching and learning activities, as well as assessment activities. Hence, the efficient use of digital technologies is challenging.

Based on current scientific findings on lecturers' need for training for a digital transformation in the South African TVET sector, the TRAINME 2 programme has been developed in order to promote in-service lecturer's Technological Pedagogical Content Knowledge (TPACK).

Holler, [illegible] Zinn (2023): How [illegible] African TVET lectur[illegible] digital compe-tenc[illegible] what is their need[illegible] aining for a di[illegible] ansformation in [illegible] South Afr[illegible] TVET [illegible] ctor?

In Module I.1, conditions for an effective usage of digital tec[illegible]ol-ogies is discussed, focusing on their didactic p[illegible]tential as w[illegible] as the necessary competencies of teachers. You will g[illegible] overv[illegible] of a variety of digital technologies that you can use f[illegible]fective[illegible] learning processes and in the design of your lessons. You [illegible]ll also [illegible] use of the introduced digital technologies at different stations (hand-[illegible] practice) [illegible] develop innovative scenarios with reference to your tea[illegible]ing subjec[illegible] uring implementation at your college, you will transfer your new kno[illegible] and [illegible]s into practice.

OBJECTIVES

At the end of Module I.1, [illegible] will b[illegible] to

- reflect o[illegible] constitutes th[illegible] ity of [illegible] igital tec[illegible] in teaching and [illegible] processes,
- [illegible] der the s[illegible] learning objective, context and pe[illegible] gical appr[illegible]
- se[illegible] igital educatio[illegible] ntent (teaching / learning [illegible] al),
- [illegible] derstand different licenses attributed to digital content and the implications for their re-use,
- create new and digital educational content (teaching / learning material),
- [illegible] odify and edit existing digital content, where this is [illegible] itted,
- combine and mix existing digital resources or parts thereof, where this is permitted,
- create a lesson plan for a technology-enhanced lesson.
- integrate digital technology in a didactically meaningful way in the classroom

HOW TO USE THIS BOOK

This course book is an introduction to using the digital technologies as a tool for 21st century teaching and learning at TVET colleges. The book is divided into two primary sections. Section 1, the Library, introduces the theoretical background and current state on the technology-enhanced teaching and learning. Section 2, the Workshop, gives an overview of great digital technologies that can facilitate every-day teaching and learning. The Workshop sets out essential concepts and skills relating to the ability to understand and use digital technologies (e.g. creating, sharing, assessing). The techniques suggested are tried and tested; they draw on both academic research and best practises. A toolbox gives insight to va igital technologies: from the presentation tool to subject specific technologies. e too box is only available in the digital format of the book.

The book include a selection of the following teaching resources:

- Further reading recommendations with links
- Teaching and/or learning objective
- Tips for lecturers
- Web and video links

By working through this module, you can ild your te ing repertoire step by step, starting with strategie are easy implement and moving on to those that will help your students develo ir sk still further. Always work with another lecturers or lecturer wh the same class. Discuss which strategies are the ost effec and why. Find someone to pair up with and team-teach. Design th asks to her. I ntify sections of the unit that are particularly relevant t ou a fo on those

The cou book acc anies t workshops, where handouts and activities are provid

re is sp in this study guide for you to write notes and responses to some of t questions. some tasks, you might make an audio recording or video in ac- n. You could sh e this, along with any other notes with your teacher colleagues.

Explanation of Icons

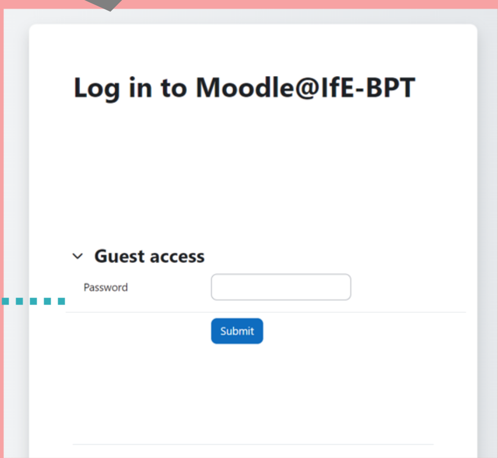
Further reading
recommendations with links

Wel d video l

Cross refer

an the QR cod text, video or web page would open.

Scan code to view and download the digital course book



Chapter 1

DIGITAL COMPETENCE

1 CONCEPTUALISATION

Digital competence has emerged concurrently with global transformations due to digitalisation and digitisation and is the most recent concept describing technology-related skills. ICT skills, technology skills, information technology skills, 21st century skills, information literacy, digital literacy, and digital skills have also been used to describe the knowledge, skills and attitudes of using digital technologies and are often used as synonyms.

The approach to the conceptual definition of digital competence has shifted from a technical orientation to a broader understanding taking non-routine interpersonal and non-routine analytical skill, such as originality, agility, critical thinking and problem-solving as key operational components into account (Ferrari 2012; van Laar et al. 2020).

Hence, the term competence is more used than skills reflecting the need for a wider and more profound content of the concept (Ilomäki et al. 2011). In reviewing frameworks collected from government and non-government agencies, the following notions recurring consistently: access, manage, understand, integrate, communicate, evaluate and create. In line with this, a most recent definition is provided by EU:

> *Digital competence involves the confident, critical and responsible use of, and engagement with, digital technologies for learning, at work, and for participation in society. It includes information and data literacy, communication and collaboration, media literacy, digital content creation (including programming), safety (including digital well-being and competences related to cybersecurity), intellectual property related questions, problem solving and critical thinking (EU 2018: 9).*

Ilomäki et al. (2011): What is digital competence

2 COMPETENCE AREAS AND COMPETENCES

The importance of digital competence is evidenced by the many national and regional efforts to develop and implement digital literacy frameworks and strategic plans to reinforce citizens' digital literacy. Various policy documents address this fact. In Germany, for example, competences for a digital world are described in the strategy paper Bildung in der digitalen Welt (Education in the digital world) of the conference of Ministers of Education and Cultural Affairs in 2016 [illegible]e year later, the European Commission published DigCompEdu. South Africa fo[illegible]ce adopted the Microsoft Digital Literacy Standard Curriculum Version 4 and [illegible]DL frameworks (cf. Law et al. 2018: 32). Most frameworks (including [illegible]) cover [illegible]e DigComp framework to a high degree. Taking the DigComp 2.1 framew[illegible] r[illegible]r-ence there are five key areas and eight proficiency leve[illegible] [illegible]ompeten[illegible]

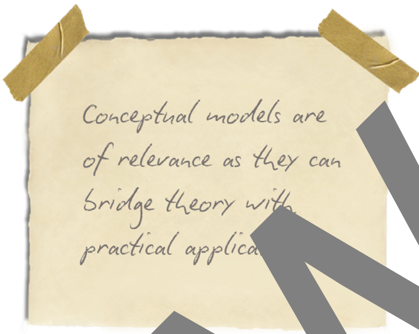
Figure 1 DigComp's five key areas and 21 [illegible]mpetenc[illegible]

A Global Framework of Reference on Digital Literacy Skills for Indicator 4.4.2

[illegible]igComp 2[illegible] [illegible]ital C[illegible]ce

Source: Extracted from Carretero et al. 2018: 14

3 TEACHER'S DIGITAL COMPETENCE



In addition to the technical, organisational and infrastructural requirements as well as the needs of the learners, the professionalism of the teachers is a key success factor for teaching and learning in the digital world and thus for the acquisition of subject-specific and interdisciplinary skills by students (KMK 2016). For example, competence area 6 of the DigCompEdu framework shows that teachers are responsible for the mediation and promotion of learners' so-called digital key competencies. Based on the descriptions in chapter 1, the question immediately follows as to which professional competencies teachers (or lecturers) must have to integrate digital technologies didactically meaningfully into the classroom.Since educators are role models for their students, it is vital for them to be equipped with the digital competence all citizens need to be able to actively participate in a digital society (Redecker 2017). For example, the strategy paper Bildung in der digitalen Welt (Education in the digital world) of the conference of Ministers of Education and Cultural Affairs in 2016 describes teachers' competences in dealing with digital technologies. Among other things, teachers should be able to:

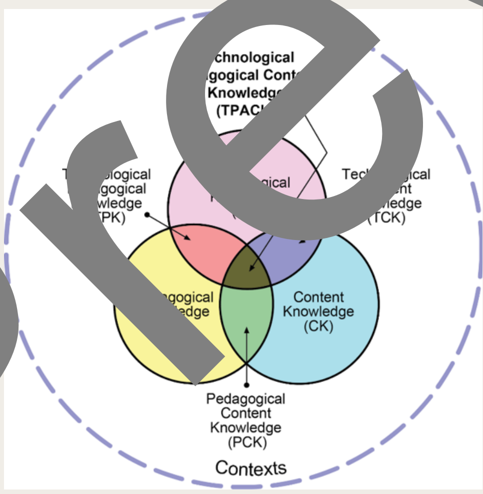
- continuously develop their own general media competence, i.e., to be able to handle technical devices, software and programs, learning platforms, etc., in order to be able to prepare lessons, also in collegial cooperation, networking administrative tasks, as both use of digital media in the classroom, and the secure handling of data (KMK 2016),
- learning-theoretical and didactic possibilities of digital media promoting support for individuals and groups individuals or groups, in or outside the classroom,
- to support students in learning through or for media so that they can critically reflect on the growing range of available media, make meaningful choices, and use them appropriately, creatively, and socially responsibly.

Based on the Policy on Professional Qualifications for Vocational Education Lecturers (DHET 2012), South African (newly) professionally qualified lecturers must be personally competent users of digital technologies, as well as being able to effectively integrate digital technologies into teaching and learning; this may be the use of language learning applications for first and second language education, as well as simulation software for mathematics learning (DCDT 2020). Furthermore, it is a strong consensus that teachers need appropriate conceptual understanding to guide the integration process in order to effectively use technology in education (Tondeur et al. 2021).

Internationally, a wide range of concepts & models are developed and used in research and/or practice focusing on technology integration in education, for example:

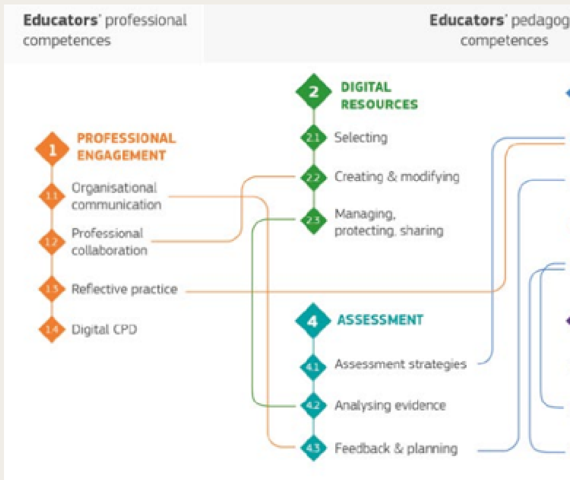
- TPACK Modell (Koehler & Mishra 2009)
- DigCompEdu-Modell (Redecker 201[illegible])
- UNSECO ICT Competency Framework for Teachers ([illegible])

Figure 2 TPACK Modell



Source: Extracted from Koehler & Mishra 2009: 63

Figure 3 DigCompEdu-Modell



Source: Extracted from Redecker & Punie 2017: 16

Figure 4 U O IC mpetency Framework for Teach

Source: Extracted from UNESCO 2018: 10

Chapter 2

INTRODUCTION TO DIGITAL TEACHING & LEARNING

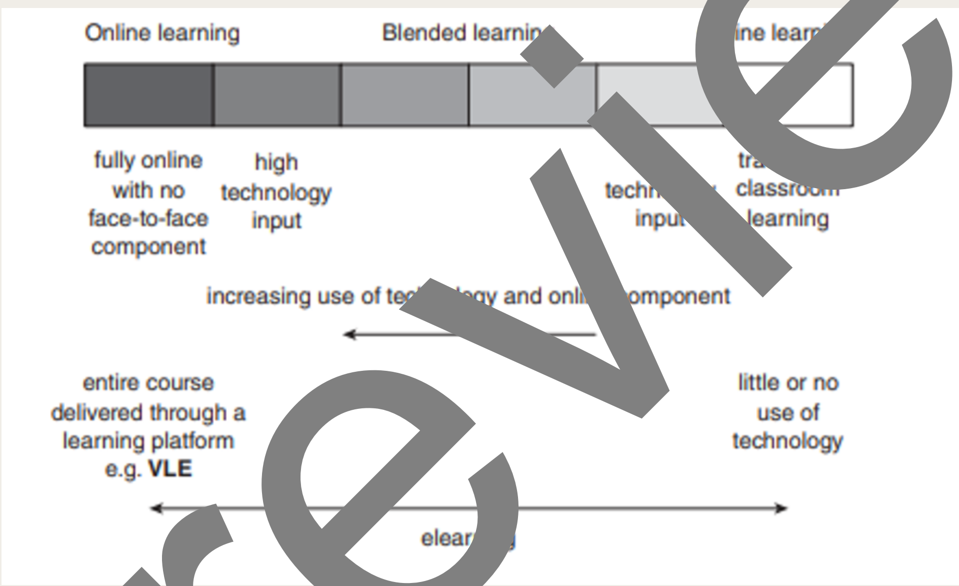
1 ONLINE LEARNING, E-LEARNING, DIGITAL LEARNING: WHAT IS THE DIFFERENCE?

E-Learning – or electronic learning – has been referred to as technology-enhanced learning, and more recently as digital learning (W[illegible]er 201[illegible]) and describes the digitalisation of the entire teaching and learning experience. The learning content is conveyed into interactive [illegible]ks or s[illegible] using different delivery modalities. This is done with the help of electronic texts, sound, images, video or animation. Digital learning also describes a [illegible] of technology-mediated methods that can be applied to support student learning. Online Learning is one modality of digital teaching and learning. Learners learn with the help of the internet. In online learning, lesso[illegible]-recorded, or a learner can attend on-demand lectur[illegible]

Educational (research) literature presents inconsistent views of the term digital learning. A few different definitions of digital learning are provided below:

- Digital learning i[illegible] information communication technologies to support the learner's interaction with digital materials designed to help learners reach specific learning outcome (Vovides 2019).
- Digital learning refers to learning that is facilitated by technology and gives learners some control over time, place, path and/or pace (Manzoor 2016).
- Digital learning encompasses instructional practices that use digital technology to strengthen or augment a student's learning experience.
- Digital learning is any type of innovative learning that is accompanied by technology or by instructional practice that makes effective use of technology which encompasses the application of a wide spectrum of practices such as blended and virtual learning (Elçi 2020).

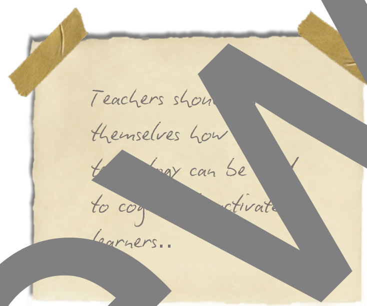
Figure 5 The relationship of e-learning to distributed learning



Extracted from Mason & Rennie 2006: 14

2 POTENTIAL OF DIGITAL TECHNOLOGIES FOR TEACHING & LEARNING

Whether the integration of a digital tool leads to a better learning outcome is a complex question, which on the one hand requires dealing with the concept of learning and research methodological problem. An agreement exists that digital technology – when integrated into a program that aligns curriculum, instruction, and assessment in a rigorous and constructivist learning environment – has a number of potential to contribute to different facets of educational development and effective learning: expanding access of information, improving presentation, improving the quality of learning, enhancing the quality of teaching, and improving classroom management. For learning the potential is on the level of cognitive activation, climate of learning and classroom management (KMK 2021; Lachner et al. 20[illegible]).



Haalem et al. (2022): Understanding the role of digital technologies in education: A review

Research has shown positive effects of digital technologies on student engagement, flow experience & motivation, and learning outcomes (Fokides & Kefallinou 2020; Heindl & Nader 2018; [illegible] & Smyrniou 2017; Moyer et al. 2018).

Lin et al. (2016): A Study of the Effects of Digital Learning on Learning Motivation and Learning Outcome

Meta-analyses on the use of notebook [illegible]ls (Zheng et al. 2016) and tablets (Haßler et al. 2015) [illegible] a positive correlation between the use of mobile media and students' academic performance. Based on an evaluation of 110 experimental and quasi-experimental studies on learning with mobile devices from the period 19[illegible]–2013, [illegible] et al. (201[illegible]) report a mean effect size of 0.523 or that 69.95% of learners performed significantly better than those without mobile digital technologies.

01 Individuality and Creativity

02 Discovery Learning and Experimentation

03 Action and Product Orientation

04 Variability & Change Between Forms of Presentation

05 Interactivity and Vividness

06 Communication Collaboration

07 Comb differ Learn Spaces

Acces y and Inclusio

Individual Feedb k

Poten of digital technologies on the level of cognitive activation, classroom management and climate of learning (cf. KMK, 2021)

Digital technologies do not only deliver content and improve subject specific knowledge and skills, but rather improve students' own digital competence, e.g. the safe, responsible and ethical use of digital technologies (Redecker 2016). It is assumed that the use of digital technologies can support independent and co-operative work processes (Schaumburg & Prasse 2019: 172), communication and problem-solving skills (Redecker 2016).

Digital Technologies also offer possibilities in lifelong learning, adult training an[illegible] e-training for the workplace (cf. Haddad & Draxler 2002; Stürmer & La[illegible]er 2018). Teachers can make efficient and innovative use of technologies when pl[illegible] implementing, and assessing teaching and learning. Digital technologies [illegible]ke it easier for teachers to create and modify educational content a[illegible] share[illegible]e content with their students. Teachers will also be able to innovate the[illegible]ch[illegible] methods—and make their lessons or instruction mor[illegible]tere[illegible] engaging, [illegible] effective. Digital technologies fundamentally chang[illegible]he desig[illegible] teaching and learning (Jahnke 2017; Puentedura 20[illegible] Whether [illegible]rking[illegible]th a si[illegible]e student or large numbers of students face-to-face o[illegible] online, [illegible]ers will be[illegible]le to make timely, targeted interventions and provide p[illegible]nalise[illegible]dback[illegible]individuals along the way. Hence, the students wi[illegible]e more [illegible]vely engaged, have a better learning experience and increase their [illegible]husiasm [illegible]earning.

THE DIGITA[illegible]EBATE

In 2001, M[illegible] Prensky, a [illegible]ar American writer and speaker on educat[illegible] coined [illegible]erm dig[illegible]natives – or net genera-ti[illegible] Goog[illegible]n[illegible]on or millenn[illegible] – to refer to young people [illegible]o grew up [illegible]echnology. A[illegible]tal native is assumed to be [illegible]aturally proficie[illegible]gital technologies. However, [illegible]arch has found that the idea of a digital native is a myth and th[illegible] no significant difference between millennials and older genera[illegible] regarding their skill in using technology. Young people hav[illegible]ry diverse uses, attitudes and experiences of technology. Surveys in South Africa also revealed that even the so-called digital natives lack basic digital skills (Czerniewicz & Brown 2013; Matli & Ngoepe 2021).

Eyon, R. (2020): The myth of the digital native: Why it per-sists and the harm it inflicts

Bennett et al. (2008): The 'digital natives' deba-te: A Criti-cal Review of the Evidence

The<< kids< are (probably) alright, but not "digital natives" with Katya Bozukova

Scan to play Video

- **10** Selecting, Creating & Modifying Content
- **11** Sharing, Researching & Documenting
- **12** Communicating & Collaborating
- **13** Visualising, Animating & Simulating
- **14** Structuring & Systemising
- **15** Assessing & Diagnosing
- **16** Facilitating Learners' Digital Competence

Teachers (and students) can m[illegible] use [illegible]ital tech[illegible]logies for

Read more in [illegible] digital co[illegible]book.

Digital Competence

Digital competence has emerged concurrently with global transformations due to digitalisation and digitization and is the most recent concept describing technology-related skills. ICT skills, technology skills, information technology skills, 21st century skills, information literacy, digital literacy, and digital skills have also been used to describe the knowledge, skills and attitudes of using digital technologies and are often used as synonyms.

3 MORE EMPIRICAL RESULTS

Both subject-specific learning and interdisciplinary skills can be promoted with small to medium effects. On average, digital technology (media) has a demonstrable, albeit rather small, positive effect (0.30 to 0.37).

Furthermore, technology is used to stimulate cognitive activity (e.g. note-taking) and constructive and constructive (e.g. argumentation) activity of the learners. For example, the effects of digital presentations are small (0.11) as well as those of animations (0.37) , serious games (0.30-0.35) and cognitive tutors (0.44-0.50). Interactive videos (0.50) are stronger, [illegible] creating concept networks with concept mapping applications most strongly (0.82). Consistent with this, constructivist learning environments in the field of mathematics were found to be effective, giving learners an active-constructive role and often also allow cooperative learning (0.4[illegible]). It should be noted, that not every use of technology (media) is equally effective. Among [illegible] PowerPoint is probably one of the most widely used digital technology, but it offers no demonstrably added value beyond the effect of a good teacher lecture. The impact of digital technology, on the other hand, is all the greater the more it is used to bring students into an active or constructive role, for example with interactive videos, exercises with feedback, simulations (e.g. Ge[illegible]) or a guided web research, in preparation for a class discussion. Thus, a Digital Learning Environment (or technology-rich environments) is a system in which the learner can use new technology to assist them in learning new information and skills. This can be through technologies such as PC, tablet, mobile phone – any electronic product that allows you to learn something. The system encompasses the technological tools, curriculum, context, and the teacher who is equipped to leverage the tools in service of teaching the curriculum and promoting student learning.

EFFECT SIZES

The effect of digital media is determined using so-called effect sizes. Small (from 0.2), medium (from 0.5) and large (from 0.8) effect and large (from 0.8) effect sizes correspond to probabilities of 56%, 64% and 72 %, respectively, that a randomly selected person who is taught a particular method achieves a higher learning success than a randomly selected person who is not taught with the help of this method.

Hillmayr et al. (2020): The potential of digital tools to enhance mathematics and science learning in secondary schools: A context-specific meta-analysis

Zinger et al. (2017) conceptualises technology-rich environments in the classroom, as for example providing access to digital technology, developing skills with digital technology, and enacting and supporting usage of digital technology.

Zinger et al. (2017) also argues that technology-rich environments' may exist in unexpected places and with limited resources, if teachers are able to effectively leverage those resources in ways that support the curriculum and student learning.'

The impact depends strongly on how they are integrated into the learning process. Therefore, teachers should reflect why they plan to use specific technologies in a certain way: What content should be taught? What should their students learn? What are prerequisites and constraints at colleges or for their students at home? What knowledge and learning experiences do they bring to the table? What learning habits do they have? Which teaching and learning scenarios are best suited? Which technology (media) mix is suitable?

Computer Simulation & Virtual Reality

Teaching and learning can be made more vivid through computer simulation & virtual reality, for example students of architecture can call up information about the buildings on their smartphones and on their smartphones during excursions and record their own evaluations on site. Students learn statistics more easily if they can use an app to practice on a real example. Furthermore, preparing students via virtual labs can increase the effectiveness of practical exercises in real laboratories. For instance, Park (2019) found that after working with a computer simulation on physical concepts, the students predicted and explained the given scientific phenomena with more valid scientific ideas. Especially for the communication of complex processes several studies point to the potentially highly effective suitability of simulations (Sarabando et al. 2016; Smetana & Bell 2012). Regarding the enhancement of traditional instruction with computer simulation, Jimoyiannis & Komis (2001) investigated the effect on students' understanding of basic kinematics concepts concerning simple motions through the Earth's gravitational field.

In their intervention, the students who used the computer simulation in addition to traditional instruction achieved significantly higher results on the research tasks. Berger ([illegible]) noted that students exhibited greater motivation when engaged in a computer-based physics experiment as opposed to a hands-on experiment. S[illegible] et al. ([illegible]) similarly compared two groups of students, both of which were taught a curriculum on the kinetic molecular theory. The students, who spent additional class periods using the computerised simulation, scored significantly higher than the students in the control group (Cohen's d ¼ 0.81) on a test measuring their understanding of the theory. Besides positive effects, empirical studies report several cognitive and metacognitive difficulties for students learning with computer simulations (Jong & van Joolingen 1998; Köck 2018). This is mostly due to the high cognitive load that results from working on these complex systems (Jong, 2010). Also Stern, Barnea & Shauli (2008) indicated that overall achievement was very low and long-term learning differences negligible. The authors attribute this to a lack of sound teaching strategies, i.e., addressing students' prior knowledge, and guiding their interpretations of learning experiences.

Videos

Alten et al. (2019): Effects of flipping the classroom on learning outcomes and satisfaction: A meta-analysis

Kostaris et al. (2017): Investigating the Potential of the Flipped Classroom Model in K-12 ICT Teaching and Learning: An Action Research Study

van Wyk (2019): Flipped Class Pedagogy as a Digital Pedagogical Strategy in an Open Distance E-Learning Environment

The theoretical foundations for dealing with, for example, explainer videos include studies that examine the effectiveness of learning with explainer videos. Several studies prove this for both the reception and the production of explainer videos. Researchers demonstrated that the use of explainer videos (as opposed to paper-based materials) enhance learning performance (cf. Lloyd & Robertson 2[illegible]; van der Meij & van der Meij 2014), as well as the attention and motivation of learners (cf. Ifenthaler 2015). According to the cognitive theory of multimedia learning, videos, face-to-face classes, and videoconferences could all maximise th[illegible] of our cognitive infrastructure (Mayer 2008).

Flipped Classroom

The results of the meta-analysis show that secondary school students benefit from the flipped classroom principle. The results show significant and positive overall effects on the learning performance of students in all three comparison categories. The greatest overall effect with [illegible]14 was found in the 'pre-post comparison' category. In two other (stricter) categories the overall effects are small but still substantial and significant. This means that students through flipped classroom learned more than students in regular classes; for post-test comparisons, the effect size is d = 0.[illegible] and for change comparisons, d = 0.45. This can serve as evidence that flipped classroom instruction can be more effective than traditional classroom off[illegible]

4 PROBLEMS AND LIMITATIONS OF DIGITAL (EDUCATIONAL) TECHNOLOGIES

Empirical results show that openness to new technologies should be accompanied by an awareness of their limitations or disadvantages and teachers need to think carefully about when, why and how to use technologies as well as evaluating their efficiency and effectiveness. For example, digital technologies are sometimes associated with myths, such as that digital natives have – thanks to new communication technologies – neuronal structures or a great potential for multitasking, both of which have been disproved by empirical evidence (Kirschner & de Bruyckere 2017). Studies also show, for example, that the use of pens activates deeper neural processes than the use of the keyboard. Results prove direct electrophysio-logical evidence that drawing by hand activates larger networks in the brain than typing on a keyboard (Mueller & Oppenheimer 2014). In a d[illegible]ital world, information seems to always acc[illegible] pany us, in our pockets and ba[illegible] Easy access to [illegible]tion, however, does not necessarily make learning [illegible]sier; a[illegible]ccess to content does not necessarily mean that a person learns. Acc[illegible]ding to [illegible]wey (1910) we learn not from experience, but from reflective prac[illegible] – [illegible] a smar[illegible]one, a tablet or a laptop itself cannot make the user r[illegible]t (Jah[illegible]t al. 2012)[illegible]rthermore, the implementation of technologies [illegible]e classroo[illegible]y be costly and time-consuming, e.g. for [illegible]hase o[illegible]nical equipment or the expansion / conversion of premises.

> **COGNITIVE EXTRO[illegible]XION**
>
> 'Cognitive extroflexion' means t[illegible]itiv[illegible] operations a[illegible]l from the hu[illegible] brain. A[illegible]ample woul[illegible]hat today, compared t[illegible]e past, w[illegible]ly re[illegible]ber any telepho[illegible]umb[illegible] because th[illegible]re stored in our mo[illegible]one. Such tech[illegible]ogies carry [illegible]rtain ris[illegible]gniti[illegible]vation will be re[illegible]l (deskilling).

See [illegible]e 32: Prerequites and Constraints in the Use of Technology for Education

[illegible]re may be problems with the existing infrastructure, for example internet [illegible]ections may be inconsistent and/or slow.

The [illegible]f digital resource requires more legal requirements have to be observed

See Page 120: Copyright & Open Educational Resources in your digital course book

and compared to analog media such as textbooks, e.g. in terms of data protection and copyright.

Safety for students and teachers is a key challenge with prevention of cyber-bullying, the hacking of personal information, access to illegal or banned materials and distractions from learning (such as social networking and mobile phone use), all being high on institutional agendas. Some uses of technologies can be physically harmful. For example, poor posture and eyestrain are common problems when working at desktop computers for prolonged periods. Also, Repetitive Strain Injury (RSI) is a risk that occurs from the repeated actions necessary to control mobile devices.

5 POTENTIALS OF DIGITAL TECHNOLOGIES IN TVET

Vocational education and training must consider two major topics of interest:

- **Social participation**
- **Vocational Action Competences**

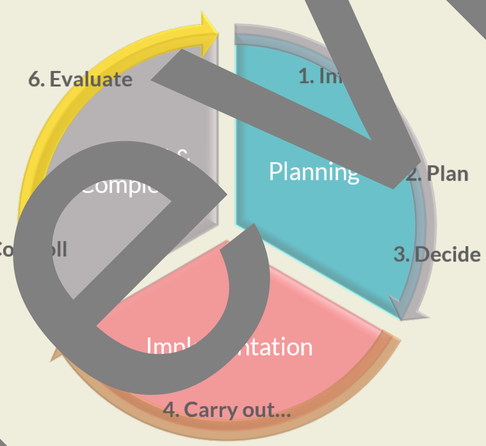
Digital technologies offer opportunities to strengthen action orientation in the classroom and to integrate informal forms of learning into formal learning (Seufert et al. 2018). Also, Howe & Knezek (2018) argue that digital technologies are particularly suitable for promoting professional competence. They illustrate this potential using the example of learning and work tasks – the key didactic concept for the interconnected implementation of work process orientation and subject – guiding principle in vocational education and training.

Excurses / Recap
Learning and Work Tasks
in your digtal course book

DIGITAL TECHNOLOGIES FOR LEARNING AND WORKING TASKS

Skilled workers are confronted with correspondingly demanding expectations such as independence, a sense of quality and responsibility, cooperation, communication and interaction skills, an understanding of operational processes, interrelationships and value chains, flexibility, creativity, etc. Holistically trained skilled workers with comprehensive professional action and organization competence are therefore required.
The promotion of professional competence is oriented towards projects and problem-based situations of professional reality (cf. Howe & Berben 2006). Learning in problem-based situations takes place by means of learning and work tasks that form a link between vocational training and work environment. Learning and work tasks consists of four steps: acceptance, planning, implementation, and control and completion of an assignment. At the same time the five digital competences (see DigComp Edu on page 16) are promoted if technologies are implemented in the realization of the learning and working tasks (Howe & Knutzen 2013, see figure 6).

Figure 6 Cyclus of Learning / Works T… and Me…se



Source: Created by author

Chapter 3

DESIGN OF DIGITAL TEACHING & LEARNING

1 TEACHING & LEARNING ENVIRONMENT

A Learning Environment is an ecosystem of people, values, practices, content, physical spaces and technology. It is the classroom, lab, online spaces, and library; the teachers and students; the course curriculum and materials; the learning activities; and the integrated tools and devices, all of which are essential for learning, communication, and collaboration.

Veletsianos (2016): Digital Learning Environments

Borri (2021): From Classroom to Learning Environment

The use of technologies changes didactics in the classroom: whiteboard or blackboard are no longer the centre of educational processes, but instead active student participation and individualised learning. The role of the teacher also changes from being the central contact person to being a companion. Thus, a Digital Learning Environment (or technology-rich environments) is a system in which the learner can use new technology to assist them in learning new information and skills. This can be through technologies such as a PC, tablet, mobile phone – any electronic product that allows you to learn something. The system encompasses the technological tools, curriculum context, and the teacher who is equipped to leverage the tools in service of teaching the curriculum and promoting student learning.

Zinger et al. (2017) conceptualises technology-rich environments in the classroom, as for example providing access to digital technology, developing skills with digital technology, and enacting and supporting usage of digital technology. Zinger et al. (2017) also argues that technology-rich environments 'may exist in unexpected places and with limited resources, if teachers are able to effectively leverage those resources in ways that support the curriculum and student learning.' The impact depends strongly on how they are integrated into the learning process. Therefore, teachers should reflect why they plan to use specific technologies in a certain way: What content should be taught? What should their students learn? What are prerequisites and constraints at colleges or for their students at home? What knowledge and learning experiences do they bring to the table? What learning habits do they have? Which teaching and learning scenarios are best suited? Which technology (media) mix is suitable?

Figure 7 Evolution of a New Paradigm

FROM	TO
A school building	A knowled[illegible] infrastr[illegible] (schools, [illegible] televisio[illegible]ernet, mu[illegible])
Classrooms	Individual [illegible]rs
A teacher (as provider of knowledge)	A teacher (as a[illegible] and facilitator)
A set of textbooks and some audiovisual aids	M[illegible] materi[illegible]rint, audio, video, digital...)

Source: Extracted from Ha[illegible]d & Dra[illegible] 2002:

2 PREREQUISITES AND CONSTRAINTS IN THE USE OF TECHNOLOGY FOR EDUCATION

Teachers and their competences are central to the (digital) learning environment. However, other contextual factors also influence teaching and learning. According to Haddad & Jurich (2012) an effective use of learning technology depends on:

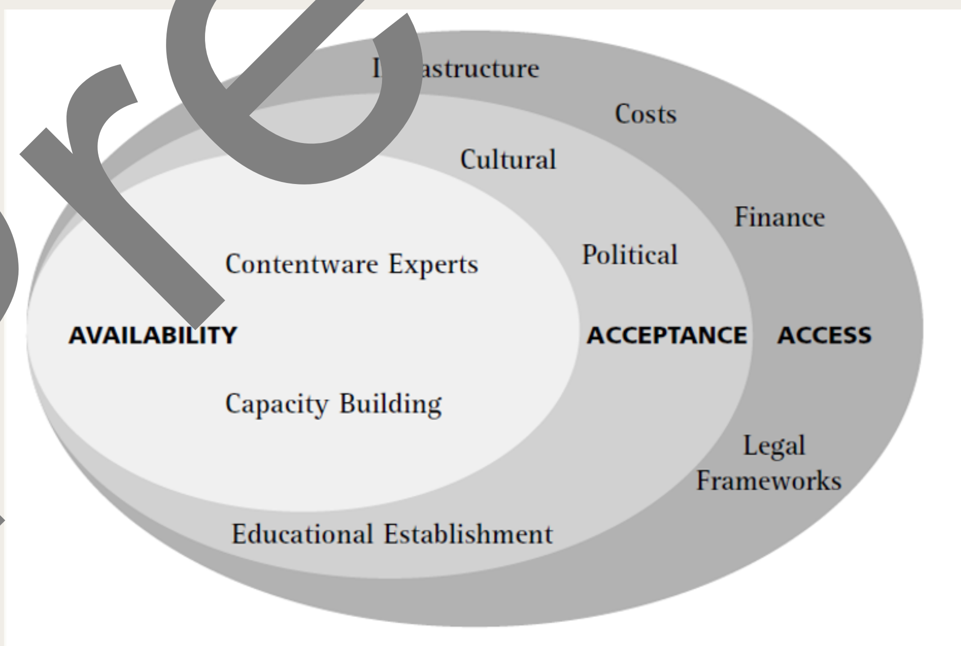
Access: Basic requisites for the installation and use of technologies

Acceptance: Cultural and political factors that create or promote barriers to technology projects

Availability: Technology-related factors that facilitate or hinder project implementation

However, the effective integration of technology may be more dependent on curriculum and instruction than the particular technological tool (Earle 2002). In the context of access, skills, and usage, technology-rich environments are dependent on the teachers who instruct the student as much as they are dependent on the availability and affordances of the technology itself (Zinger et al. 2017).

Figure 8 The rel[illegible] to distributed learning



Source: Extracted from Haddad & Jurich 2002: 8

Haddad & Jurich (2002): Technologies for Education

3 BARRIERS TO TECHNOLOGY INTEGRATION EDUCATION

Although research (e.g. Elliot & Mikulas 2012; Tamin et al. 2011; Zielezinski & Darling-Hammond 2016) has demonstrated that student achievement improves with the use of technology, certain barriers impede teachers from integrating digital technology into their classrooms. Ertmer (1999) identified first-order or external barriers and second-order or internal barriers.

First-order barriers are external to teachers. They are associated with availability of resources (Ertmer 1999). First-order barriers exist across nations, from those with limited to high levels of technology (Goktas et al. 2009; Keengwe et al. [illegible]). Lack of high-speed internet access and time challenges related to student access to ICT and teacher development and planning time is a first-order barriers (du Plessis & Webb 2012). Furthermore, technical support emerges as a common barrier and universal prerequisite for successful pedagogical practices in technology-rich classrooms in developed countries such as the United States (Warschauer 2011) as well as developing countries such as Nigeria, where lack of technical support was found (Tella et al. 2007). Even schools with sufficient resources may have difficulty keeping up with the ever-evolving need for increased bandwidth and computing power, frequent needs for device updates and hardware obsolescence. However, this barriers are necessary but not sufficient condition for technology use in the classroom (Ertmer [illegible]; Wilfried et al. [illegible]).

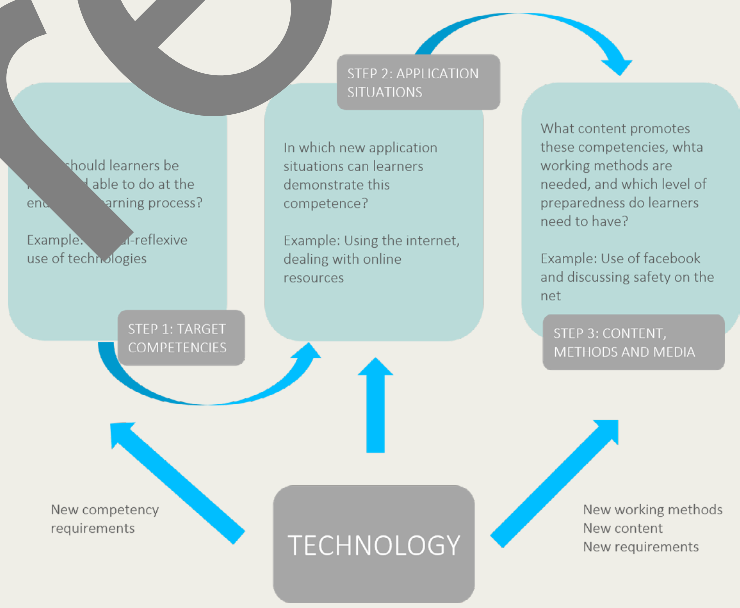
Second-order barriers associated with teachers include teachers' beliefs about the role of technology in their classroom, beliefs about their own teaching, and the willingness or ability to change their practice (Ertmer 1999). From a skill and usage perspective, if teachers' beliefs do not align with effective technological pedagogy, then it is unlikely that students will have opportunities to develop their own skills and usage of technology. Second-order barriers are influenced not only by personal attitudes, but also by social contexts, cultural landscapes, and learned pedagogical practices (Ertmer 1999). For example, in studying the use of computers in an ESL class, Warschauer (1998) found incongruences between the teacher's and students' visions of using computers for writing. The conflicting visions led to student disengagement and a lack of interest in the work of the class. Particularly, teachers' beliefs & attitudes are relevant for technology integration (Ertmer 2005, 2015; [illegible] 2020).

4 DESIGNING A DIGITAL LEARNING ENVIRONMENT

When you design a digital learning environment you must understanding the potential of technologies to meet different objectives (e.g. the development of digital competence). Different objectives do not only affect the choice of technologies but also the modalities of use (Haddad & Draxler 2002). Krommer (2015) and Dillenbourg (2013) argue that when it comes to the use of technology in the classroom, neither the only presence of (the quality of) the technology nor objectives or unreflective orientation to the real world should be the basis of lesson planning (Krommer 2015: 42).

Various principles and models from cognitive psychol[illegible]hn, Ropo[illegible] Groß: 11), which illustrate and research the capacity [illegible]d perfor[illegible]nce of human memory, are conceptually guiding th[illegible]sign of mu[illegible]media [illegible]arnin[illegible]nvironments with digital technologies.

Figure 9 New [illegible]nologi[illegible]pact [illegible]ning and learning processes



Source: Created by author, based on www.lehren-und-lernen.ch

Dillenbourg (2013): Design for classroom orchestration.

5 DIGITAL TECHNOLOGY INTEGRATION MODELS

5.1 THE SAMR MODEL

Digital technologies can be integrated in different modalities. Even if a fundamental, generalizing, empirical foundation does not exist, the SAMR (Substitution, Augmentation, Modification, Redefinition) model is a planning tool that may h[illegible] to design better learning activities for students. The model is a four-level, taxonomy-based approach. It shows the stages of technology integration in educational settings.

How to Apply the SAMR Model with Ruben Puentedura

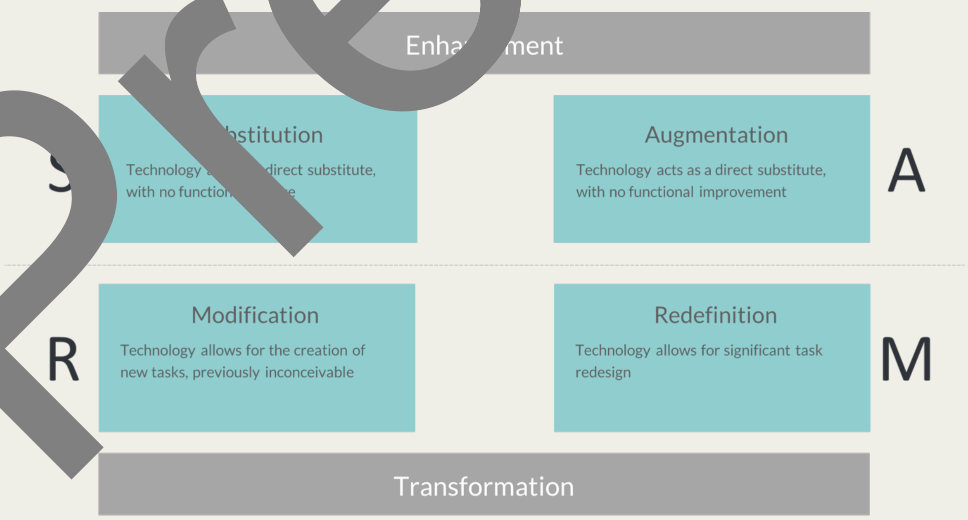
Scan to play video

Critical Review and Suggestions for Its Use

Despite its increasing popularity, there is yet a theoretical explanation of the SAMR model in the peer-reviewed literature. A challenge for implementation is the absence of context, its hierarchical structure, and the emphasis placed on product over process is (cf. Hamilton 2016).

Hamilton et al. (2016): The Substitution Augmentation Modification Redefinition (SAMR) Model: A Critical Review and Suggestions for its Use

Figure 10 SAMR-Model



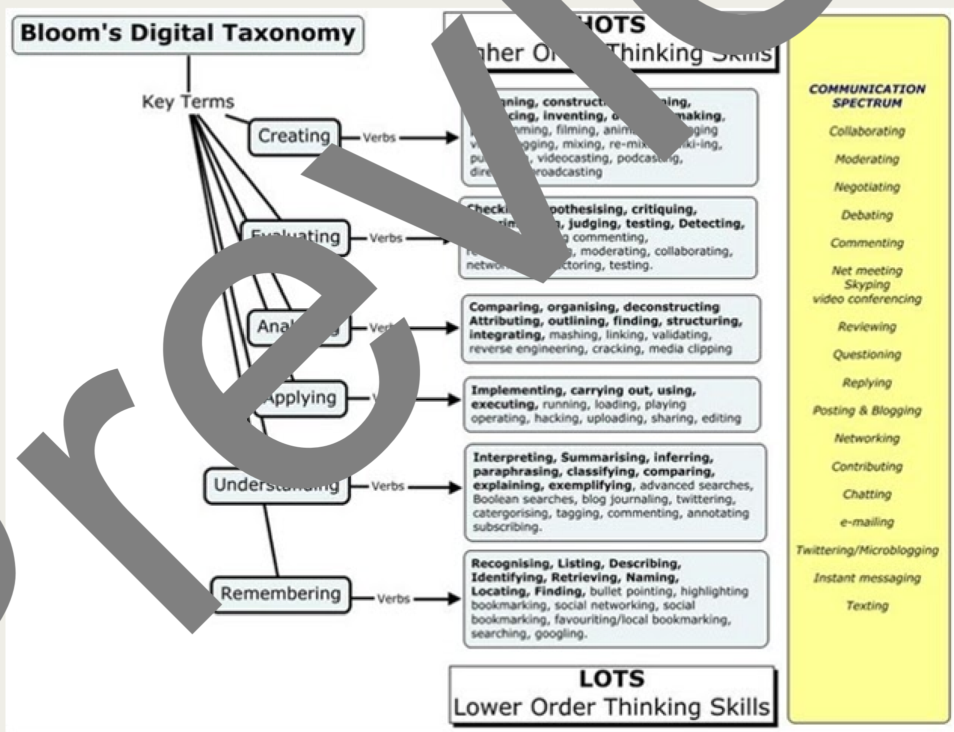
Puentedura (2010): SAMR and TPCK: Intro to Advanced Practice

Source: Created by author, based on Puentedura 2010

5.2 BLOOM'S DIGITAL TAXONOMY

Bloom's Taxonomy has also been adapted to show how ICT tools and technologies can facilitate learning. One such adaptation is the integration of technology into the taxonomy, resulting in what some might call Bloom's Digital Taxonomy. This adaptation involves reimagining how technology can enhance and support each level of cognitive skill development. In this context, each level of the original taxonomy can be connected to specific technological activities and tools that aid in achieving those cognitive goals (see figure 11).

Figure 11 Bloom's Digital Taxonomy



Source: Extracted from Churches 2008: 7

Churches … Bloom's … Taxo- nom…

5.3 GROUNDED TECHNOLOGY INTEGRATION

Based on the argument that effective technology integration necessitates a blend of content knowledge, technological expertise, and pedagogical insight (Koehler & Mishra 2008; Mishra & Koehler 2006), Harris et al. (2010) propose a rational approach to assist educators in enhancing the integration of technologies into their teaching. This approach involves directly connecting students' content-related learning requirements with specific content-based learning activities and the corresponding educational technologies that are most conducive to the successful execution of these activities. In mathematics, for instance, Harris et al. (2010) have identified 31 learning activity types that have divided into seven categories:

- The *Consider* Activity Types
- The *Practice* Activity Types
- The *Interpret* Activity Types
- The *Produce* Activity Types
- The *Apply* Activity Types
- The *Evaluate* Activity Types
- The *Create* Activity Types

Table 1 Sample Evaluate Mathematics Activity Types

ACTIVITY TYPES	BRIEF DESCRIPTION	EXAMPLE TECHNOLOGIES
Compare and Contrast	The student compares and contrasts different mathematical strategies or concepts, to see which is more appropriate for a particular situation	Inspiration, Web searches, Mathematica, MathCad
Test a Solution	The student systematically tests a solution and examines whether it makes sense based upon systematic feedback, which might be assisted by technology	Scientific calculator, graphing calculator, spreadsheet, Mathematica, Geometry Expressions

Source: Created by author, based on Harris et al. 2010: 584

Harris et al. (2010): "Ground-ed" Technology Integration: Instructional Planning Using Curriculum-Based Activity Type Taxonomies

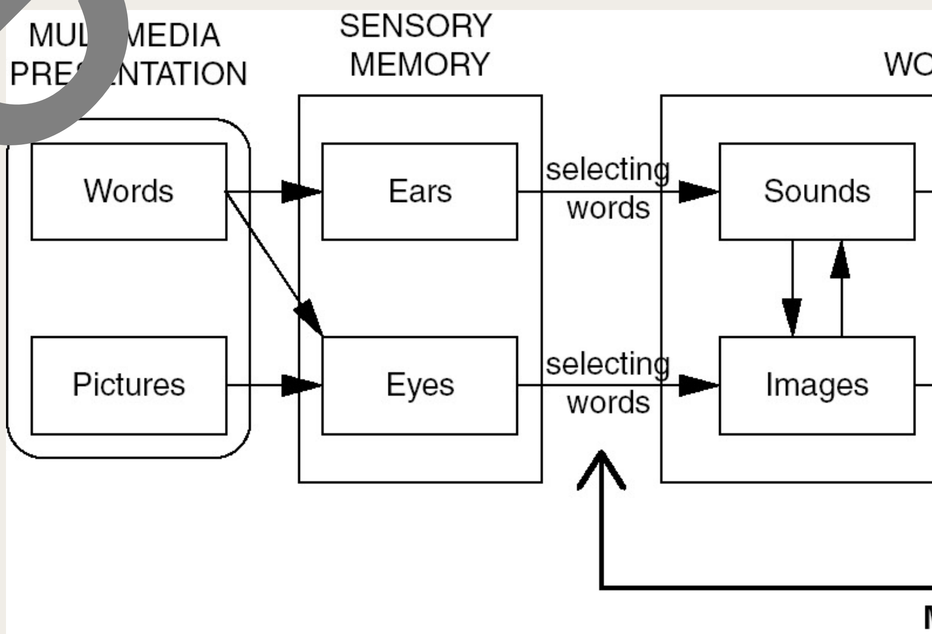
6 MULTIMEDIA LEARNING THEORY

Multimedia Learning Theory (MMLT) was originally developed by Richard Mayer in 1997. It falls under the grand theory of Cognitivism. According to Mayer (1997), the key idea of the theory is that students can learn more effectively when they are given two or more media and are engaged in processes of selecting the most relevant materials, organizing them into cognitive mental representations, and finally integrating them with their prior knowledge. This theory proposes three main assumptions when it comes to learning with multimedia:

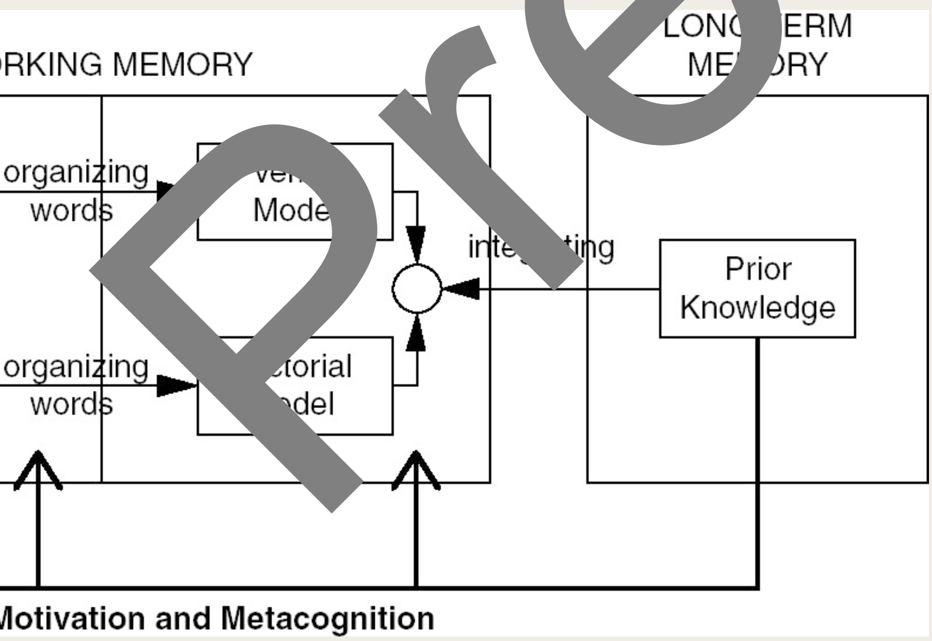
- There are two separate channels (auditory and visual) for processing information (sometimes referred to as Dual-Coding theory);
- Each channel has a limited (finite) capacity (similar to Sweller's notion of Cognitive Load);
- Learning is an active process of filtering, selecting, organizing, and integrating information based upon prior knowledge.

Mayer's cognitive theory of multimedia learning also relies heavily on cognitive load theory (CLT; e. g. Chandler & Sweller, 1991, 1992; Sweller, 2005).

Figure 12 Cognitive Theory of Multimedia Learning



Source: Extracted from Mayer 2014



Mayer (1997): Multi-media Learning: Are We Asking the Right Questions?

7 LEARNING FOR AND THROUGH DIGITAL TECHNOLOGIES

Digital technologies can be incorporated into the design of learning processes in different ways, depending on several objectives and the didactic focus.

Learning for technology

Education for technology encompasses the broad field of digital literacy with three aspects:

- Technological: includes the ability to choose the right technology [illegible] lar task, combined with a basic exploratory attitude.
- Cognitive: includes knowledge of programming (e.g. for 3D printing), computational thinking, networking in the context of the Internet of Things, robotics, Big Data analysis. The internet, for example, enables rapid access to a huge amount of information. Immersive simulations with augmented/virtual reality make it possible to have realistic experiences in a specially environment created for this purpose. Mind tools can support reflection and metacognition.
- Ethical: promotes an informed and critical attitude, e.g. with regard to security and data protection issues, net[illegible] often addressed in the context of media education.

Learning for technology

Education through technology encompasses the use of technologies that

- can support / assist learning (e.g. assistive technology that can read out text to people who cannot read it themselves or simulate a classroom when a student cannot attend in person),
- help students perform certain tasks (e.g. computer, printer, 3D printer), and
- help facilitate students' own digital competence.

8 WAYS OF COMMUNICATION

Communicating with teachers and students is an important factor to acquire knowledge (Schulmeister 2003: 159). Different means of communication can generally be grouped into:

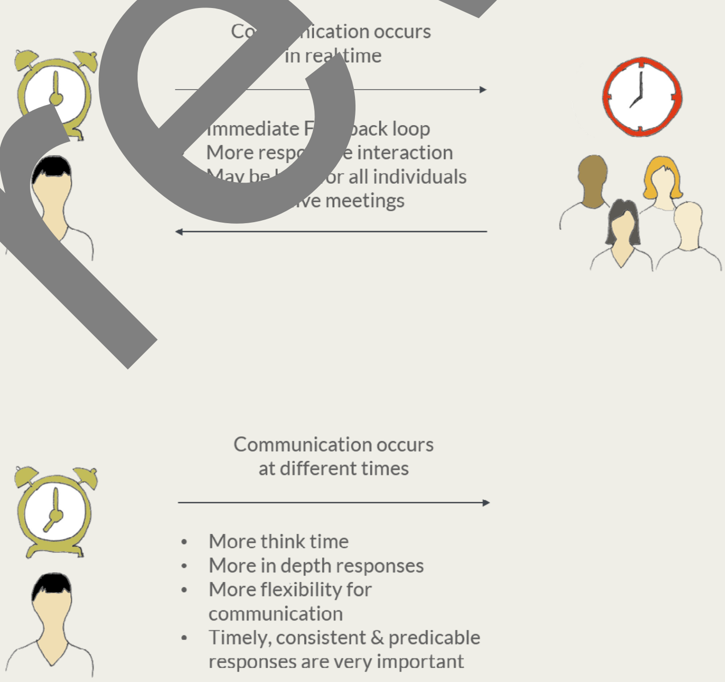
Synchronous communication: Interactive, live (real time) interchange between people.

Synchronous learning thus offers a fixed time frame for learning activities. Another advantage is that communication takes place (almost) without time delay. This enables direct interaction between the participants.

Asynchronous communication: Participants of discourse don't have to respond or participate immediately.

Advantages of asynchronous learning are that learners can work at their own pace and repeat content as often as they like; answers, e.g. to questions in forums can also be thought through more carefully than in face-to-face learning situations.

Figure 13 Ways of Communication



Source: Created by author

9 FORMS OF DIGITAL LEARNING

Digital teaching and learning takes various forms: individual (Individual Learning), collaborative (Collaborative Learning), game-based (Game-Based Learning), with stories (Storytelling), immersive (VR, 360-degree/3D), and with cognitive AI applications or as a combination of several forms (Möslein-Tröppner & Bernhard 2021).

Individual Learning

Individual learning is self-directed and at the student's own pace. It is guided by one's own interests and enables individual learning paths - outside of the classroom. But it can also be part of a flipped-classroom. A[illegible]rning can offer such opportunities, as it can address both auditory and visual learning types. Characteristics of individual learning:

- however (e .g. leaners use a smartphone or other device)
- whoever
- whenever
- and wherever.

The different forms of creating and using [illegible]ing videos, audiobooks, podcasts or eBooks are individual learning forms (Möslein-Tröppner & Bernhard 2021).

Social / Collaborative Learning

Digital collaboration involves the use of digital technologies for collaboration regardless of the location of the participants.

Examples:
- Online Courses
- Blended-Learning Courses
- Group Work

Social learning means learning together and from each other through the technologies that have been publicly available since Web 2.0. Examples for Social Learning:

Examples:
- Social Network Communities (e.g. Linkedin, Facebook)
- Chat & Video Meeting
- File Sharing

Game-Based Learning

Game-Based Learning means learning on the basis of games. Basically, games offer a high entertainment value and are fun. They challenge the player and motivate him to pursue the game goal. Associated with this is a reward for one's own result - depending on how one proceeds in the game, this can be higher or lower.

You can play individually or in groups with each other (cooperative) or against each other (competitive). If you don't play alone, you can play at the same time (synchronous) or time-delayed (asynchronous).

Examples:
- Scenarios
- Interactive Videos
- Simulations
- Quizzes
- Programming (e.g. Lego Mindstorms & Sp[illegible]

Storytelling

People find it easy to remember content when it is packaged in stories. Stories are up to 22 times more memorable than facts or or numbers (Delistraty 2014). Teachers can use digital storytelling in two different ways. ways:

- The content is integrated into the stories by the teachers themselves
- The learners create their own story on a given topic and to present it to the students (Möslein-Tröppner & Bernhard 2021).

Examples:
- Podcasts
- Visual Storytelling
- Animations

Immersive Learning

Immersive learning provides individuals with an 'interactive learning environment, either physically or virtually, to replicate possible scenarios or to teach particular skills or techniques. Simulations, role play, and virtual learning environments can be considered immersive learning' (https://trainingindustry.com/glossary/immersive-learning/).

Examples:
- 360° / 3D Learning
- VR-Gamebooks
- Escape Rooms
- Virtual Classrooms
- VR-/AR-/MR-Applications such as google expeditions etc.

The motivations of using virtual reality (VR) in teaching are: learning efficiency, time problems, physical inaccessibility, limits due to a dangerous situation and ethical problems.

Cognitive AI-Apps

AI-Applications based on intelligent algorithms. They provide valuable assistance for learners.

Examples:

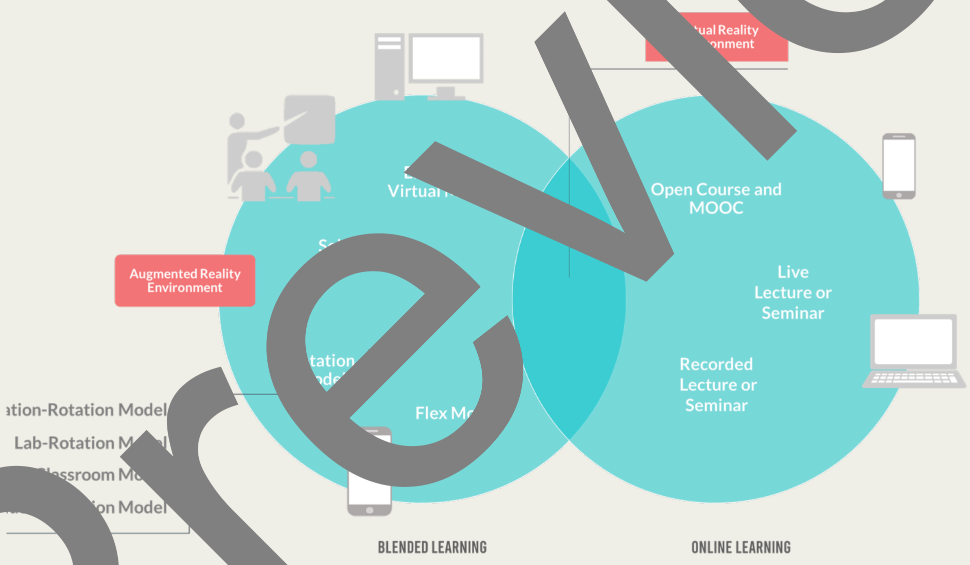
- language processing apps (e.g. translation apps such as DeepL)
- text processing,
- image processing,
- data processing

10 DIGITAL TEACHING AND LEARNING MODALITIES, SCENARIOS & METHODS

The integration of digital technology encompasses different approaches to teaching and learning. It refers to the blend of digital technology and skills into face-to-face learning. Digital technologies are also used to support online learning in a variety of scenarios using various methods.

- **Blended Learning**
- **Online Learning**

Figure 14 Overview of Digital Teaching and Learning



Sour[illegible]reated by author

10.4 BLENDED LEARNING

Attempts by scientists to outline the concept of Blended Learning demonstrate different ways of understanding of its content:

- Online with face-to-face teaching and learning
- Courses that are taught both in the classroom (face-to-face) and from a distance
- Traditional teaching and learning is supplemented (enriched) with technology to allow learners to control their own learning pace. Benefits are role play, mentoring, hands-on practice, and feedback

In blended learning, there are three different types of activities that can be combined with each other (cf. Alonso et al. 2007):

- Self-paced e-learning: Here the students can choose themselves the time and its duration, the tempo, and the place of their learning activities (Learning anytime and anywhere).
- Live e-Learning: Synchronised form of e-learning, for example, lectures as webcast or working in a virtual classroom at a specific time. This makes it possible for the students to ask the teacher questions or take part in discussions with other students.

Kerres et al. (2003): A didactical framework for the design of blended learning arrangements

10.5 ONLINE TEACHING AND LEARNING

Online learning is **education that takes place over the internet**. Instruction may be synchronous or asynchronous, and various technologies can be used to mediate the process.

First of all, online teaching must also meet didactic requirements or design principles that already apply in offline teaching: Student activation, learner orientation, learning goal/competence orientation, etc.

However, their possibilities for interaction differ significantly from those of a classroom teaching, since digital tools are used here (such as the virtu[illegible]ass-room, online seminars, chats). Online as well as offline, the learning process [illegible] be supervised by teachers – at least at appropriate intervals.

Table 2 Overview of Digital Teaching and Learning Modalities, Sce[illegible] [illegible]ethods

WORK STEP / TIME	GOAL	CONTENT SYNCHRONOUS/ ASYNCHRONOUS	METHO[illegible]S / SOCI[illegible] FORM[illegible]	[illegible]SESSMEN[illegible] [illegible]BACK	[illegible]EDIA
Arrival 07:55 - 08:00 h	Checking technology, informal exchange	Arrival in the virtual asynchronous teach-learn-room			BBB, Startslide, maybe music
Entrance & Activation 08:00 - 08:15 h	The participants get to know each other. A good work environment is created.	Participants get t[illegible] each other	Check-in metho[illegible] [illegible]ntrance. e.g. Pictu[illegible] [illegible]tion	presenting each o[illegible]er	Digital picture gallery, BBB, maybe turning on the camera and audio
Orientation Input 08:15 - 08:45 h	The participants receive a thematic overview, also on the organization process, goals & use, [illegible] and know what to e[illegible]	Pres[illegible] of the topics, [illegible]tion [illegible]s, relevant tools, …	Lecture	[illegible]nquiries	Slides Presentation via BBB Share-screen via BBB
Activating prior knowledge 08:45 - 09:20 h	The participants [illegible]e to connect their p[illegible] knowle[illegible]e to the [illegible]	Entrance i[illegible]opic	[illegible]estionnaire [illegible]k - pair - share: [illegible]ange in small groups in [illegible]kout-rooms [illegible]nstorming & clustering	Shared notes participant's flips	BBB, shared notes, Board-Tool
Mediation	[illegible]articipants receive [illegible]-depth view into the [illegible] and understand [illegible]tion	[illegible]ing of a topic [illegible] dig[illegible]	[illegible]elf-study units are worked through alone, with a learning-tandem or in a studygroup, independent from time and location.	Exercises, quizzes, (self-)tests	Self-study material, BBB, Board Tools for collaborative work
Conclus[illegible] 09:20 - 09[illegible]	The [illegible]ts give feedba[illegible]ent and know abou[illegible]er approach and [illegible]	Conclusion, Feedback, outlook/prospects	Plenum exchange	5 Terms Flash feedback-method	Slides Shared notes

S[illegible]: Created by author

11 TEACHING STRATEGIES

Teaching (or instructional) strategies are what teachers do to facilitate student learning (Dabbagh & Bannan-Ritland 2005). According to Jonassen et al. (1991), instructional strategies are 'the plans and techniques that the instructor/instructional designer uses to engage the learner and facilitate learning' (p. 34) a represent 'a plan, method or series of activities, aimed at obtaining a specific goa (p. 31).

In traditional learning environments, students need more than just stru guidance; they also require a deliberate arrangement of experie ces to fac tate the attainment of their desired performance improvements. her w ds, teachers must create a stimulating learning environment f the purpo viding guidance, but also the necessary strategies, a arryin activities t will facilitate learning, and help develo appropria behavio or th learning objectives (cf. Akdeniz 2016), the need be kept in nd. se stra ies are also relevant for digital learning. In the related erature, e are a lot re concepts of strategies which can be classified int diff t categ

Figure 15 Classificati tructional stra

Author	Classification systems									
Saskatchewan Education (1985, 1991)	Dire ction	ve instructi	Independent/individual study	Experiental instruction	Indirect instruction					
Merrill (1987)	Regulation	Message strategies	Orientation strategies							
Sedgwik (199	Give u age	Warn / Alerted	To be informed / To inform	Volunteer / Make voluntary	Win / Bring					
Marzano	entifying similarities and differences		Reinforcing effort and providing cognition	Ho nd e	Nonlinguistic representations such as mental images, graphs, acting out content	Cooperative learning	Setting objectives and providing feedback	Generating and testing hypotheses	Activating prior knowledge via questions, cues, advance organizers	
	Effective instru	Teacher oriented strategies	Student-oriented strategies							
Ray (2	Web-based strategies									
	Encouragement of dent-centered instruction	Encouragement of student collaboration	Encouragement of effective learning	Giving prompt feedbacks	Emphasizing on-time duties	Create high expectations	Supporting implicit learning			
Huang (2006)	Brain-based strategies									
	Cognitive domain group	Affective domain group	Physico-motor domain group							
	W	Left brain str.	Right brain str.	Metacognitive str.	Security and trust str.	Attention str.	Social-interaction str.	Physical environment str.		
Killen (2007)	Direct ins	Discussion str.	Small group discussions str.	Cooperative instruction str.	Problem-solving str.	Inquiry str.	Role playing str.	Case studies	Writing str.	
Bazan (2007)	Student directed str.	Teacher directed str.	Without instruction design str.							
Edvantia (2005)	Macro strategies	Micro-strategies								
	Metacognition	Active student engagement	Higher order thinking	Cooperative learning	Independent practice/homework					
Eri şti & Akdeniz (2012)	Focus strategies	Process strategies								
	Instructor oriented str.	Learner-oriented str.	Problem solving-case studies str.	Discussion, brainstorming str.	Modeling, simulation, role playing str.	Thinking, criticize, comment str.	Presentation str.	Question – answer str.	Writing, summarizing, taking notes str.	Project, investigation str.

Source: Extracted from Instructional Strategies by Akdeniz 2016: 64

Akde 6): Instruc tional St

12 METHODS AND TECHNIQUES

Traditionally, strategies can be collected in four groups. These groups are generally associated with the instructional and learning models of Bruner, Ausubel, Piaget Dewey or Vygotsky (Akdeniz 2016):

- Presentation strategies
- Discovery strategies
- Inquiry strategies
- Cooperative / Collaborative strategies

In this study guide only appropriate teaching methods and tech[illegible]r traditional strategies are introduced.

Table 3 Classifications of instructional strategies

GROUP	KEY POINTS	METI[illegible] & TECHNIQUES
Presentation strategies	• Teacher-centered • Deductive reasoning • Informative instruct[illegible] • Abstract to concr[illegible] • Preprocessing informatio[illegible] • Acquisition	question and a[illegible]cture, case study, [illegible]iscussion, brainst[illegible] demonstration etc.
Discovery strategies	• [illegible]r-centered • [illegible]uctive reasonin[illegible] • [illegible]omprehensiv[illegible]uction • [illegible]oncrete to[illegible]ct • [illegible]infor[illegible]s and sample[illegible] • [illegible]	Brainstorming, role playing, question & answer, discussion, debate, drama, analogy, case study etc.
Inquiry strat[illegible]	• Learn[illegible] • Deductive [illegible]ve reasoning • Higher-order thinking • Experiential • Problem-solving • Analysis, synthesis, evaluation, [illegible]lection, creation	Trip, observation, individual study, experiment, lab, case study, problem-solving, etc.
[illegible]erative / [illegible]llaborative strategies	• Learner-centered • Group studies/social interaction • Work sharing • Democratic values • Problem-solving and case studies • Analysis, synthesis, evaluation	Problem solving, case study, inquiry, Learning Together, Think-Pair-Share, teams-game-tournament, Cooperative Integrated Reading and Composition (CIRC), jigsaw, etc

Source: Created by author, adapted from Instructional Strategies by Akdeniz 2016: 67

13 FORMS OF ACTION AND SOCIAL FORMS

For the learning at home, in addition to individual work, forms of partner work and group work can be taken into account, for example, by using online-based collaborative variants to work together on documents or to create digital products such as presentations, explanatory videos, podcasts, etc. During these phases, video links, video telephony or chats enable the communication within the team. This promotes social contact between the learners and allows the teacher to join in to gain an insight into the work status and procedures of the groups. Technically less complex forms are also conceivable and useful, such as a partner puzzle, in which partner teams work out a content in a division of labour, then explain their respective topic to each other over the telephone and email the joint result to their teacher.

Individual work

Each individual work requires a clear work assignment. Possibilities for checking and securing results should already be considered when setting the task.ered when setting the task.

Table 4 Notes on individiual work regarding digital teaching and learning

DIDACTIC-METHODICAL NOTES	TECHNICAL NOTES
Students work on materials or tasks e.g. from textbooks, worksheets or internet sources.	Formulate work assignments Specify the media to be used, if necessary, provide a QR code Possibly offer solutions for self-marking (uploaded to server or cloud) Possibly save results (e.g. server or cloud)
Students practice and review content individually using digital platforms and get immediate feedback on their learning progress.	Digital exercises are used or created by the students themselves, e.g. with LearningApps, LearningSnacks, Kahoot, Mentimeter
Students create materials that will be digitally provided to all.	In addition to the analogue work results (texts, charts, flyers, etc.), which are made available to everyone digitally, the development of digital exercises (e.g. LearningApps, LearningSnacks) or explanatory videos (e.g. with MySimpleShow or with smartphones) by the students is also possible.

Source: Created by author, adapted from Emmermann et al 2021: 52

Partner work/Group work

In the digital version, the same instructions for the formulation and provision of tasks and materials apply as for the individual work. In these social forms, the possibilities of checking and securing results should also already be considered when setting the task.

Table 5 Notes on partner / group work regarding digital teaching and learning

DIDACTIC-METHODICAL NOTES	TECHNICAL NOTES
Collaborative opportunities support joint work, with several students working on a document at the same time, regardless of location.	At some schools, a school server offers the possibi [illegible] together in a document via the cloud. Other variants: Goog [illegible] or Padlet.
The discursive oral exchange in the collaboration can take place via breakout rooms.	Digital communication betwee [illegible] ral people is po [illegible] for exampl [illegible] via Zoom or BigBlue [illegible] n.

Source: Created by author, adapted from Emmermann et al [illegible] 1: 53

Table 6 Notes on partner / group work [illegible] egarding digit [illegible] aching and le [illegible] ning

DIDACTIC-METHODICAL NOTES	[illegible] AL N [illegible] S
Information is digitally prepared as a lectu [illegible] access. Text-image-(sound)-variants a [illegible] cal, sometimes [illegible] interactive forms. These can be deve [illegible] by the teach [illegible] e students.	There are differe [illegible] s of preparing information, and there are digital tools for this, e.g. • lectures with PowerPoint, Adobe Express, Google Slides etc. • Screen-cast videos with CamStudio • interactive lectures with ThingLink, TEDME • explanatory videos with MySimpleShow

[illegible] : Create [illegible] uthor, adapted [illegible] mmermann et al 2021: 53

Classroom discussion

A virtual classroom discussion cannot be as spontaneous as a classroom discussion and therefore needs to be carefully planned.

The two examples show different variations for the design of digital lessons.

In **example 1,** the teacher provides the trainees with assignments and materials to work on individually. Analogue tasks and materials are replaced by digital technology (media). The tasks remain the same, only the media changes. According to the SAMR model, this corresponds to the substitution stage. The trainees can structure and complete their tasks time-independently; the classroom discussion of the face-to-face lessons to secure results is replaced by a video conference (Emmermann et al. 2021: 56).

Example 2 shows lessons with students who are being trained exclusively according to § 66 of the Vocational Training Act. The stages of the lesson are implemented in a way comparable to face-to-face teaching. The media provided for this purpose is retained. The teacher accompanies the learning process in video presence, guides and gives feedback. The lessons are designed to support social contacts even without the face-to-face teaching. Digital technology is used in accordance with the SAMR-Model for the functional extension of learning processes (Emmermann et al. 2021: 56).

Table 7 Notes on classroom discussion regarding digital teaching and learning

DIDACTIC METHODOLOGICAL NOTES	TECHNICAL NOTES
Questions are asked, solutions are presented, and contents are worked on in a joint discussion in the virtual space.	Digital communication between several people is possible, for example, via Zoom or BigBlueButton. Collaborative work in the virtual classroom can be supported by giving everyone access to content that has already been created and is stored in a cloud, or by using interactive boards such as those in Padlet, Kahoot or Flinga. The structuring of lessons can be visually supported by Classroomscreen.

Source: Created by author, adapted from Emmermann et al 2021: 53

Notes

Akdeniz C. 2016. Instructional Process and Concepts in Theory and Practice: Improving the Teaching Process. Singapore: Springer. http://gbv.eblib.com/patron/FullRecord.aspx?p=4746692

Moore W A & Smith A R 2012. Effects of video podcasting on psychomotor and cognitive performance, attitudes and study behaviour of student physical therapists. Innovations in Education and Teaching International, 49:4, 401–414. DOI: 10.1080/14703297.2012.728876

Alonso F et al. 2007. An instructional model for web-based e-learning education with a blended learning process approach: British Journal of Educational Technology, 36: 2, 217–235.

Panagiotis A & Bowman D. 2014. Evaluating the effects of orchestrated, game-based learning in virtual environments for informal education. In Proceedings of the 11th Conference on Advances in Computer Entertainment Technology (ACE ,14). Association for Computing Machinery, New York, NY, USA, 4, 1–10. Retrieved September 5, 2023 from https://doi.org/10.1145/2663806.2663821

Baskerville et al. 2019. Digital First: The C[illegible] tological Reversal and New Challenges for Information Systems Research. MIS Quarterly. 44:2, 509–523. D[illegible] MISQ/2020/14418

Berger M. 2018. Neue Medi[illegible]m expe[illegible]entellen Physikunterricht d[illegible] Seku[illegible]rstufe I: Eine empirisch-[illegible]rativ[illegible]e zur Untersuchung de[illegible]uswirkung[illegible] von virtuel[illegible] durchgefü[illegible] physikalische[illegible] [illegible]n auf d[illegible]tivation der Lernenden im S[illegible]ndarstufe[illegible]reich I. Dissertation, Pädag[illegible]sche Hoch[illegible]le Heidelberg, Heidelbe[illegible]

Bonaiut[illegible] G, Calvani A, Men[illegible]etti L & Viva[illegible] G. 2017. Le tecnologie educative [illegible]ducational technologies]. Carocc: Rom.

[illegible]und M & Reiss M. 2006. Towards a More [illegible]uthentic Science Curriculum: The Con[illegible]tion of Out-of-School Learning. Int[illegible]tional Journal of Science Education, 28, 1[illegible]3–1388.

Chen C-H, Liu J-H, & Shou W-C. 2018. How Competition in a Game-based Science Learning Environment Influences Students' Learning Achievement, Flow Experience, and Learning Behavioral Patterns. Journal of Educational Technology & Society, 21:2, 164–176. Retrieved September 5, 2023 from http://www.jstor.org/stable/26388392

Cheng J, Wang Y, Tjondronegoro D & Song W. 2018. Construction of interactive teaching system for course of mechanical drawing based on mobile augmented reality technology. International Journal of Emerging Technologies in Learning, 13: 2, 126–139. Retrieved September 5, 2023 from https://doi.org/10.3991/ijet.v13i02.7847

Chernikova et al. 2020. Simulation-Based Lea[illegible]ning in Higher Education: A Meta-Analysis. Review of Educational Research, 90:4, 499–541. Retrieved September 5, 202[illegible]m https://doi.org/10.3102/003465[illegible] 3544

Churches, A. 2008. Bloom's [illegible]gital Taxonomy. Retrieved Septe[illegible]5, 2023 from https://www.researchgat[illegible]/pub[illegible]ation/228381038[illegible]Digital_Tax[illegible]

Cummins S, Be[illegible]ord A R &[illegible] A (2015). Investigatin[illegible]ngageme[illegible] with In-Video Quiz Questions[illegible]a Prog[illegible]ming[illegible]urse. IEEE Transactio[illegible]n L[illegible]ning Tech[illegible]logies, 9:1, 5[illegible]6. DOI: [illegible]9/TLT.2015[illegible]44374

Czern[illegible]z L & Br[illegible] C. 201[illegible]e habitus of dig[illegible]strangers[illegible]gher education. British Jo[illegible]l of Educational Technology, 44, 44–5[illegible]trieved September 5, [illegible]23 from http[illegible]/doi.org/10.1111/j.1467-[illegible]5.2012.01281.x

Dabb[illegible]n N & Bannan-Ritland B. 2005. Online [illegible]g: Concepts, strategies, and applica[illegible]s. Pearson Education. Upper Saddle River.

Daniela L. 2018. Didactics of smart pedagogy: Smart pedagogy for technology enhanced learning. Springer.

Department of Communications and Digital Technologies (DCDT). 2020. National Integrated ICT Policy White Paper: National Digital and Future Skills Strategy South Africa. Retrieved September 5, 2023 from https://www.gov.za/sites/default/files/gcis_document/201610/40325gon1212.pdf

Department of Communications and Digital Technologies (DCDT). 2021. Implementation Programme for the National Digital and Future Skills Strategy of South Africa – Decent Jobs for Youth, 2021. https://www.gov.za/sites/default/files/gcis_document/202203/digital-and-future-skillsimplementation-programmefinal.pdf

Department of Higher Education and Training (DHET). 2013. Professional Qualifications for Vocational Education Lecturers. https://www.dhet.gov.za/Gazette/Policy%20on%20professional%20qualifications%20for%20lecturers%20in%20technical%20and%20vocational%20education%20and%20training.pdf de Jong T. 2010. Cognitive load theory, educational research, and instructional design: Some food for thought. Instructional Science, 38:2, 105–134. Retrieved September 5, 2023 from https://doi.org/10.1007/s11251-009-9110-0

Denner M-S, Püschel L C & Röglinger M. 2018. Exploiting the Digitalization Potential of Business Processes. Business & Information System Engineering, 60:4, 331–349.

Dillenbourg P. 2013. Design for classroom orchestration. Computers & Education, 69:1, 485–492. Retrieved September 5, 2023 from https://www.learntechlib.org/p/201049/

Djukic G P 2022. Handbook of Research on Global Institutional Roles for Inclusive Development. IGI GLOBAL.

Drascic D & Milgram P. 1996. Perceptual Issues in Augmented Reality. Stereoscopic Displays and Virtual Reality Systems III, 2653, 123–134.

Elçi A. 2020. An Urgency for Change in Roles: A Cross Analysis of Digital Teaching and Learning Environments From Students and Faculty Perspective. In E. Alqurashi (Ed.), Handbook of Research on Fostering Student Engagement With Instructional Technology in Higher Education, IGI Global, 462–483. Retrieved September 5, 2023 from https://doi.org/10.4018/978-1-7998-0119-1.ch025

Elliot S & Mikulas C. 2012. Improving Student Learning Through Teacher Technology Training: A Study of the Effectiveness of Technology Integration Training on Student Achievement. In P. Resta (Ed.), Proceedings of SITE 2012--Society for Information Technology & Teacher Education International Conference (1759–1765). Austin, Texas, USA: Association for the Advancement of Computing in Education (AACE). Retrieved September 5, 2023 from https://www.learntechlib.org/primary/p/39842/

[illegible]hermann R, Spalke T, Fastenrat S. 2021. Digital unterrichten praxisnah - toolbasiert innovativ. Haan-Gruiten: Verlag Europa-Lehrmittel.

Ertmer P A. 1999. Addressing first- and second-order barriers to change: Strategies for technology integration. Educational Technology Research and Development, 47, 47–61.

European Union (EU). 2018. Council Recommendation of 22 May 2018 on key competences for lifelong learning Text with EEA relevance., 2018. Retrieved September 5, 2023 from https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018H0604(01)&rid=7

Faulkner P & Runde J. 2019. Theorizing the Digital Object. MIS Quarterly, 43:4, 1–25. DOI: 10.25300/MISQ/2019/13136

Feiner S, Macintyre B & Seligmann D. 1993. Knowledge-Based Augmented Reality. Commun. ACM. 36. 53-62.

Ferracani A, Pezzatini D & Del Bimbo A. 2014. A Natural and Immersive Virtual Interface for the Surgical Safety Checklist Training. In Proceedings of the 2014 ACM International Workshop on Serious Games (SeriousGames ,14). Association for Computing Machinery, New York, NY, USA, 27–32. Retrieved September 5, 2023 from https://doi.org/10.1145/2656719.2656725

Ferrari A. 2013. DIGCOMP: A framework for developing and understanding digital competence in Europe. JRC Scientific and Policy Report, EUR 26035 EN. Institute for Prospective Technological Studies. Luxembourg.

Fokides E & Kefalou M. 2020. Examining the impact of spherical videos in teaching endangered species/environmental education to primary school students. Journal of Information Technology Education: Research, 19, 427–450. Retrieved September 5, 2023 from https://doi.org/10.28945/4612

Gaba D. 2004. The future vision of simulation in health care. Quality and Safety in Health Care, 13, i2–i10

Girwidz R. (2015). Neue Medien und Multimedia. In E. Kircher, R. Girwidz & P. Häußler (Eds.), Physikdidaktik (3rd edition), 401–427.

Guthrie H, Harris R, Simons M, & Karmel T. 2009. Teaching for technical and vocational education and training (TVET). In L. J. Saha & A. G. Dworkin (Eds.), International Handbook of Research on Teachers and Teaching, 851–863.

Haddad W & Draxler A. 2002. The Dynamics of Technology for Education. In W. Haddad & A. Draxler (Eds.), Technologies for Education: Potentials, Parameters and Prospects, UNESCO and AED, Paris and Washington, 2–17.

Haddad W & Jurich S. 2002. ICT for Education: Prerequisite and Constraints . W. Haddad & A. Draxler (Eds.), Technologies for Education: Potentials, Parameters and Prospects, UNESCO and AED, Paris and Washington, 42–56.

Hamilton M E. 2016. Imagining literacy:a sociomaterial approach. In Beyond economic interests. Sense Publishers: Rotterdam.

Hanghøj T. 2011. Clashing and emerging genres: the interplay of knowledge forms in educational gaming. Designs for Learning, 4(1), 22. Retrieved September 5, 2023 from http://www.designsforlearning.nu/11/no1/DFL_01_11_hanghoj.pdf

Harris J B et al. 2010. "Grounded" Technology Integration: Instructional Planning Using Curriculum-Based Activity Type Taxonomies. Journal of Technology and Teacher Education, 18:4, 573–605.

Haßler B, Major L & Hennessy S. 2015. Tablet use in schools: A critical review of the evidence for learning outcomes. Journal of Computer Assisted Learning, 32:2, 139–156.

Heind M & Nader M. 2018. Digital Technologies in a Design and Technology Lesson and Their Influence on a Learner's Situationally Perceived Value of a Task When Engaged in Inquiry-Based Learning. Journal of Computers in Mathematics and Science Teaching, 37:3, 239–263.

Hofstein A, & Lunetta V N. 2004. The Laboratory in Science Education: Foundations for the Twenty-First Century. Science Education, 88:1, 28–54. Retrieved September 5, 2023 from https://doi.org/10.1002/sce.10106

Howe F & Knutzen S. 2013. Digitale Medien in der gewerblich-technischen Berufsausbildung. Einsatzmöglichkeiten digitaler Medien in Lern- und Arbeitsaufgaben. Retrieved September 5, 2023 from [illegible]port.
bibb.de/[illegible]dia2013/expertise_howe-knutzen.pdf

Hsin W. J & Cigas J. (2013). Short videos improve student learning in online education. Journal of Computing Sciences in Colleges, [illegible], 253–259.

Huang H-M, Rauch U & Liaw S-S. 2010. Investigating learners' attitudes toward virtual reality learning environments: Based on a constructivist approach. Computers & Education. 55, 1171–1182.

Ifenthaler D. 2015. Learning analytics. In J. M. Spector (Ed.), The Sage encyclopedia of educational technology, 2, 447–451.

Ilomäki L, Kantosalo A, & Lakkala M. 2011. What is digital competence? In Linked. portal. Brussels: European Schoolnet.

Jahnke I. 2012. Socio-technical Learning. In N. Seel (Ed.), Encyclopedia of the Sciences of Learning (ESL), Springer: New York.

Jensen L, Konradsen F J E and Technologies I. 2018. A Review of the Use of Virtual Reality Head-Mounted Displays in Education and Training. Education and Information Technologies, 23, 1515–1529. Retrieved September 5, 2023 from https://doi.org/10.1007/s10639-017-9676-0

Razzouk R &Johnson T E. 2012. Cooperative Learning. In N.M. Seel (Ed.), Encyclopedia of the Sciences of Learning. Springer: Boston. Retrieved September 5, 2023 from https://doi.org/10.1007/978-1-4419-1428-6[illegible]

Jonassen D H. 1991. Objectivism versus Constructivism: Do We Need a New Philosophical Paradigm? Educational Technology Research and Development, 39(3), 5–14. Retrieved September 5, 2023 from http://www.jstor.org/stable/30219973

de Jong T & van Joolingen W R. 1998. Scientific discovery learning with computer simulations of conceptual domains. Review of Educational Research, 68[illegible]179–2[illegible]. Retrieved September 5, 2023 from https://doi.org/10.[illegible]7/1170753

Howe F & Berben T. 2006. Lern- und Arbeitsaufgaben. In F. Rauner (Ed.), Handbuch Berufsbildungsforschung, Bielefeld, 383–390.

Kim J et al. 2014. Understanding in-video dropouts and interaction peaks in online lecture videos. Proceedings of the first ACM conference on Learning@ scale conference.

Kindley R. 2002. The power of simulation-based e-learning (SIMBEL). ELDJ. Longmire

Kirschner P A & De Bruyckere P. 2017. The myths of the digital native and the multitasker. Teaching and Teacher Education: An International Journal of Research and Studies.

Kizilcec R & Pérez-Sanagustín M & Maldonado J. 2016. Self-regulated learning strategies predict learner behavior and goal attainment in Massive Open Online Courses. Computers & Education, 18–33.

KMK [Sekretariat der Ständigen Konferenz der Kultusminister der Länder in der Bundesrepublik Deutschland]. (2016). Strategie der Kultusministerkonferenz „Bildung in der digitalen Welt". Retrieved September 5, 2023 from https://www.kmk.org/fileadmin/Dateien/pdf/
PresseUndAktuelles/2018/Digitalstrategie_2017_mit_Weiterbildung.pdf

Köck H. 2018. Fachliche Konsistenz und Spezifik in allen Dimensionen des Geographieunterrichts. In A. Rempfler (Ed.), Unterrichtsqualität Wirksamer Geographieunterricht 5. Schneider Verlag: Hohengehren, 110–121.

Krommer A. 2015. "Bring your own device!" und die Demokratisierung des Beamers. Didaktische Dimensionen digitaler Technik. In J. Knopf (Ed.), Medienvielfalt in der Deutschdidaktik. Erkenntnisse und Perspektiven für Theorie, Empirie und Praxis. Schneider Verlag: Baltmannsweiler, 36–47.

Lachner A et al. 2021. Fostering pre-service teachers' technological pedagogical content knowledge (TPACK): A quasi-experimental field study, Computers & Education, 174, Retrieved September 5, 2023 from https://doi.org/10.1016/j.compedu.2021.104304
Lam N C C. & Habil H. 2021. The Use of Video Annotation in Education: A Review. Asian Journal of University Education, 17: 4, 84–94.
Lateef F. 2010. Simulation-based learning: Just like the real thing. Journal of Emergencies, Trauma, and Shock, 3:4, 348–352.
Law N, Woo D & Wong G. 2018. A Global Framework of Reference on Digital Literacy Skills for Indicator 4.4.2.
Levasseur M. Richard L, Gauvin L & Raymond E. 2010. Inventory and Analysis of Definitions of Social Participation Found in the Aging Literature: Proposed Taxonomy of Social Activities. Social Science & Medicine, 71, 2141–2149. Retrieved September 5, 2023 from https://doi.org/10.1016/j.socscimed.2010.09.041
Lloyd, S A & Robertson, C L. 2012. Screencast tutorials enhance student learning of statistics. Teaching of Psychology, 39(1), 67–71. Retrieved September 5, 2023 from https://doi.org/10.1177/0098628311430640
Makgato M. 2019. STEM for Sustainable Skills for the Fourth Industrial Revolution: Snapshot at Some TVET Colleges in South Africa. 10.5772/intechopen.89294.
Manzoor 2016. Role of Learning Analytics in Enhancing Teaching and Learning.
Mason R & Rennie F. 2006. Elearning: The Key Concepts. Routledge: London.
Matli W & Ngoepe M. 2020. Extending information poverty theory to better understand the digital access inequalities among young people who are not in education, employment or training in South Africa. Higher Education, Skills and Work-Based Learning, 11:2, 419–436.
Mayer R E. 1989. Systematic thinking fostered by illustrations in scientific text. Journal of Educational Psychology, 81:2, 240–246. Retrieved September 5, 2023 from https://doi.org/10.1037/0022-0663.81.2.240
Mayer R E. 1997. Multimedia Learning: Are We Asking the Right Questions? Educational Psychologist, 32, 1–19. Retrieved September 5, 2023 from http://dx.doi.org/10.1207/s1532698
Middleton A. 2009. Beyond podcasting: creative approaches to designing educational audio. Research in Learning Technology. 17:2. Retrieved September 5, 2023 from https://journal.alt.ac.uk/index.php/rlt/article/view/905
Milgram, P, Kishino, F. 1994. Taxonomy of Mixed Reality Visual Displays. IEICE Transactions on Information and Systems. 12, 1321–1329.
Mishra, P, & Koehler, M J. 2006. Technological Pedagogical Content Knowledge: A Framework for Teacher Knowledge. Teachers College Record, 108:6, 1017–1054. Retrieved September 5, 2023 from https://doi.org/10.1111/j.1467-9620.2006.00684.x
Möslein-Tröppner B & Bernhard W. 2021. Digitales Learning. Was es ist und wie es praktisch gestaltet werden kann. Springer: Wiesbaden.
Moyer L Klopfer M & Ernst J V. 2018. Bridging the Arts and Computer Science: Engaging At-Risk Students through the Integration of Music. Technology and Engineering Teacher, 77:6, [illegible]–12.
Mudau P K. 2021. Lecturers' views on the functionality of e-portfolio as alternative assessment in an open distance e-learning. Int J Educ Methodol, 8:1, 81–90. DOI: 10.12973/ijem.8.1.81
Mueller P A & Oppenheimer D M. 2014. The Pen Is Mightier Than the Keyboard: Advantages of Longhand over Laptop Note Taking. Psychological Science, 25:6, 1159–1168. Retrieved September 5, 2023 from https://doi.org/10.1177/0956797614524581
Naudé W. 2017. Entrepreneurship, education and the Fourth Industrial Revolution in Africa. IZA Discussion paper No. [illegible]855.
OECD 2016. Innovating Education and Educating for Innovation: The Power of Digital Technologies and Skills, Educational Research and Innovation, OECD Publishing, Paris, Retrieved September 5, 2023 from https://doi.org/10.1787/9789264265097-en
Onyesolu & Eze 2011. Okechukwu, M., & Udoka, F. 2011. Understanding Virtual Reality Technology: Advances and Applications. InTech. DOI: 10.5772/15529
Kotsari K & Smyrnaiou Z. 2017. Inquiry based learning and meaning generation through modelling on geometrical optics in a constructionist environment. European Journal of Science and Mathematics Education, 5, 14–27. 10.30935/scimath/9494
Rackaway C. 2012. Video killed the textbook star?: use of multimedia supplements to enhance student learning. Journal of Political Science Education, 8:2, 189–200. https://doi.org/10.1080/15512169.2012.667684
Redecker, C., & Punie, Y. (2017). European Framework for the Digital Competence of Educators: DigCompEdu. Luxembourg: Publications Office of the European Union.
Richardson J, Caskurlu S & Lv J. 2017) Social Presence in Relation to Students' Satisfaction and Learning in the Online Environment: A Meta-analysis. Computers in Human Behavior, 71, 402–417.
Rizzo A A et al. 2006. A virtual reality scenario for all seasons: the virtual classroom. CNS Spectums, 11:1, 35–44.

Seufert S, Guggemos J & Tarantini E. 2018. Digitale Transformation in Schulen – Kompetenzanforderungen an Lehrpersonen Beiträge zur Lehrerinnen- und Lehrerbildung . Zeitschrift zu Theorie und Praxis der Aus- und Weiterbildung von Lehrerinnen und Lehrern, 36:2, 175–193.

Shaffer D. (2006). Epistemic frames for epistemic games. Computers & Education, 46, 223–234.

Shaw C M & Switky B. 2018. Designing and Using Simulations in the International Relations Classroom, Journal of Political Science Education, 14:4, 523–534.

Smetana, L K, & Bell, R L. 2012. Computer simulations to support science instruction and learning: A critical review of the literature. International Journal Of Science Education, 34, 1337–1370.

Spannaus W. 2012. Creating Video for Teachers and Trainers: Producing Professional Video with Amateur Equipment. Wiley.

Stern L, Barnea N & Shauli S. 2008. The Effect of a Computerized Simulation on Middle School Students' Understanding of the Kinetic Molecular Theory. Journal of Science Education and Technology, 17, 305–31[illegible] 10.1007/s10956-008-9100-z

Sarabando, C & Cravino, J & Soares, A. 2016. Improving Student Understan[illegible] the Concepts of Weight and M[illegible] with a [illegible]puter Simulation. Journa[illegible] Baltic Sci[illegible] Education, 15, 109–127.

Schaumburg, H. und [illegible]rasse[illegible] (201[illegible] Medien und Schule. Th[illegible] – For[illegible] – Praxis. Verlag Julius K[illegible]khardt: Ba[illegible]lbrunn.

Schulmeister, R[illegible]. Lernplattfor[illegible] [illegible] Lerne[illegible]ünchen, Wien. Oldenbou[illegible]

Schulthei[illegible] T, Rizzo A A[illegible]01. The a[illegible]cation of virtu[illegible]ality technology i[illegible]habilitation. Rehabil Psychol, 46: 3, 2[illegible]311.

S[illegible]eil M et al. 201). Das Konstrukt der computer- und informationsbezogenen [illegible]mpetenzen in ICILS 2013. In W. Bos [illegible](Eds.), ICILS 2013 – Computer- und info[illegible]tionsbezogene Kompetenzen von Schülerinnen und Schülern in der 8. Jahrgangsstufe im internationalen Vergleich. Münster: Waxmann, 83–112.

Seufert S, Guggemos J & Tarantini E. 2018. Digitale Transformation in Schulen – Kompetenzanforderungen an Lehrpersonen Beiträge zur Lehrerinnen- und Lehrerbildung . Zeitschrift zu Theorie und Praxis der Aus- und Weiterbildung von Lehrerinnen und Lehrern, 36:2, 175–193.

Shaffer D. (2006). Epistemic frames for epistemic games. Computers & Education, 46, 223–234.

Shaw C M & Switky B. 2018. Designing and Using Simulations in the International Relations Classroom, Journal of Political Science Education, 14:4, 523–534.

Smetana, L K, & Bell, R L. 2012. Computer simula[illegible]tions to support science instruction and lea[illegible]ng: A critical review of the literature. Internationa[illegible]urnal Of Science Education, 34, 1337–1370.

Spannaus W. 2012. Creating Video f[illegible]hers and Trainers: Producing Professional V[illegible] Ama[illegible]teur Equipment. Wiley.

Stern L, Barnea N & Shauli S[illegible]08. The E[illegible]t of a Computerized Simulation [illegible]ddle S[illegible]ol Students' Understanding of the Kin[illegible] Mol[illegible]lar Theory. Journ[illegible] Education [illegible]hnology, 17, 30[illegible]15. 10.10[illegible]10956-008-9100-z

Stern, L, Barn[illegible]L., & Sha[illegible]. 200[illegible] The effect of a compute[illegible]ed sim[illegible]ation o[illegible]iddle school students' u[illegible]ding of th[illegible]netic molecular t[illegible]y. Jour[illegible] Science E[illegible]ation and Technology[illegible]305–3[illegible]

[illegible]riuk A M[illegible]sovytska M & Shokaliuk S V. 2018. Using Bl[illegible] Augmented Reality Browser in the [illegible]ractical Tra[illegible] of Mechanical Engineers. ICTERI [illegible]rkshops.

Stro[illegible]uist N P. 2019. World Development Report 20[illegible] The changing nature of work. Internatio[illegible] [illegible]view of Education, 65:2, 321–329. DOI: 10.[illegible]007/s11159-019-09762-9

Stürmer K & Lachner A. 2017. Unterrichten mit digitalen Medien. In K. Scheiter & T. Riecke-Baulecke (Eds.), Lehren und Lernen mit digitalen Medien. München: Oldenbourg: München, 82-95.

Sung Y, Chang K, Liu T. 2015. The effects of integrating mobile devices with teaching and learning on students' learning performance: A meta-analysis and research synthesis. Computers & Education, 94, 252–275. Retrieved September 5, 2023 from https://doi.org/10.1016/j.compedu.2015.11.008

Twinomurinzi, H, Msweli, NT & Phukubje, P. 2020. Digital technologies and digital skills in organisations and government in SA. Pretoria: NEMISA and Unisa Press. Retrieved September 5, 2023 from https://uir.unisa.ac.za/bitstream/handle/10500/27620/Digital%20Technologies%20and%20Digital%20Skills%20in%20Organisations%20and%20Government%20in%20SA.pdf?sequence=1&isAllowed=y

van der Meij, H & van der Meij, J. 2014. A comparison of paper-based and video tutorials for software learning. Computers & education, 78, 150–159. Retrieved September 5, 2023 from https://doi.org/10.1016/j.compedu.2014.06.003

van Laar E, Deursen A J-A-M, van Dijk J A-G-M, de Haan J. 2017. The relation between 21st-century skills and digital skills: A systematic literature review. Computers in Human Behavior, 72, 577–588.

an Wyk, M & van Ryneveld L. 2021. Student-Generated Videos As a Learning Tool in Veterinary Education. Progressio, 41:1, 20 pages. Retrieved September 5, 2023 from https://doi.org/10.25159/2663-5895/6452

Wheeler S. 2012. e-Learning and Digital Learning. In Encyclopedia of the sciences of learning. Springer, 1109-1111.

Wieman C, Adams W, Loeblein O, Perkins K K. 2010. Teaching Physics Using PhET Simulations. The Physics Teacher, 48, 225–227.

Wiliam D. 2010. The role of formative assessment in effective learning environments. Educational research and innovation, Winther, E, Achtenhagen, F. 2009. Measurement of vocational competencies. A contribution to an international large-scale assessment on vocational education and training . In Empirical research in vocational education and training, 1, 85–102. DOI: 10.25656/01:5159

Zhang D et al. 2006. Instructional video in e-learning: Assessing the impact of interactive video on learning effectiveness. Information & Management, 43:1, 15–27. Retrieved September 5, 2023 from https://doi.org/10.1016/j.im.2005.01.00[illegible]

Zheng B, Warschauer M, Lin C-H & Chang C. 201[illegible] Learning in One-to-One Laptop Environments: A Meta-Analysis and Research Synthes[illegible] of Educational Research, 86:4, 1052[illegible]. Ret[illegible] September 5, 2023 from http://[illegible]w.jstor.o[illegible]table/44668243

Zielezinski, M B., & Darling-H[illegible] L. [illegible]. Promising practices: A lite[illegible] rev[illegible] technology use by underserve[illegible] st[illegible]dents. Sta[illegible] CA: Stanford C[illegible] for Opp[illegible]nity Policy in E[illegible]

Zing[illegible] Warsch[illegible] M. 2017. Learning [illegible] Teachi[illegible] ith Techn[illegible]y: Technological Pedagogy an[illegible] eacher Pra[illegible] In The SAGE Handbook o[illegible] search on Tea[illegible] Education 2, 577–593.

TRAINME 2

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This course book has been developed within the bilateral programme TRAINME 2 in order to promote in-service lecturers' Technological Pedagogical Content Knowledge (TPACK). The programme has been designed by the Inter-Company Training Center in Easter Bavaria (ÜBZO) and University of Stuttgart, Department of Vocational Education focused on Teaching Technology (BPT) on behalf of the German Federal Ministry of Education and Research and DLR in cooperation with the South African Department of Higher Education (DHET).