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Making in media education: An activity-oriented approach to digital literacy

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Editorial Board

ABSTRACT

Why is maker education a suitable approach for giving learners the 21st century skills they need to cope with the digital transformation? This article provides an answer and represents a defense of maker education in the field of educational science. Taking a human-media-machine interaction model as the basis for discussion, this article highlights the growing importance of digital technology as well as technological principles for human communication and interaction. Communication technology and the influence of technology on culture and society require a broad understanding of media literacy in the sense of digital literacy. By broadening the theoretical basis of media literacy education, *making*, *coding* and *tinkering* qualify as approaches for achieving these goals. The discussion uses the four classic dimensions of media literacy and action theory to argue in favor of these approaches.

Keywords: *media literacy education, maker culture, digital literacy, human media machine interaction*.

INTRODUCTION

Whoever *makes* something influences their environment and learns by interacting with it. Whoever makes something not only crafts a new object for themselves, they also have to develop an interest in making something new – they must develop an understanding of things, materials and tools and also hone their motor skills. But *maker education* is more than simply learning how to use tools – in the same way as media literacy education is more than simply learning how to use media. In the same vein, neither should making or maker education be understood merely in the sense of simply "making" something; in fact, making is actually a term for technical practice as distinct from productive media practice. This is an important distinction and one which is not drawn consistently even in publications relevant to the field (e.g. Ingold et al., 2019; Vuopala et al., 2020). This comes as something of a surprise because the distinction is of considerable importance for education: it reflects the broadening of educational goals and approaches, and the increased scope for action in media education (Knaus, 2020b). A further difference – namely the distinction between making generally and making in media education – is most apparent in the step that follows making itself, namely the maker's process of *reflection* on their actions. The opportunity to gather new experience of media and technology and engage in a collective process of reflection about them means that making is one of the most significant educational opportunities currently open to us – especially in a digitized world in which the underlying technology is an integral part of the communicative process (Baecker, 2007; Hepp, 2020; Stalder, 2018), and people are no longer exclusively in control of media (e.g. Eynon, 2013; Knaus, 2017; Selwyn, 2015; Tulodziecki, 2021). But more on this and on the two distinctions below.

Do IT yourself?

Makerspaces are workshops which give private persons access to modern production processes for making certain specific components over and above what their own domestic workshops can offer them. It is true that the Do-It-Yourself (DIY) idea is not fundamentally new. But nowadays, thanks to new technology, makerspaces offer widespread access not only to those tools that would normally be available in well-equipped private workshops, but also to machines that would be too expensive or simply too big for domestic workshops, such as 3D printers, laser cutters, CNC machines or plotters (Knaus, 2020a).

Makerspaces therefore provide everybody with access to resources and industrial production processes for individual components. The maker movement potentially enables all people – including those without extensive technical training or prior knowledge – not only to have the opportunity to customize digital media by using apps but even to develop or refine the apps themselves by coding. In addition, they can also customize the hardware and the underlying technical architecture by making use of their broad access to industrial production processes, the wide range of tutorials on how to operate them and templates for making them: Do *IT* yourself. As a result, digital technology comes to occupy a place in *everyday culture* (Engel, 2010). Paulo Blikstein (2013) – referencing Paulo Freire's *Pedagogy of the Oppressed* (1974) – views making as the democratization of invention. This is indeed a tempting thought. If only we did not have to rely on the technology and services provided to us by the big five in the internet economy and could customize media and technical artifacts not only to our own personal specifications but also design and develop them entirely by ourselves (Knaus, 2017; Knaus, 2020a).

This article seeks to show how the established approaches used in media education, supplemented by approaches from *maker education* (see also e.g. Aufenanger et al., 2017; Dezuanni, 2018; Halverson & Sheridan, 2014; Ingold et al., 2019; Ingold & Maurer 2021; Niemeyer & Gerber, 2015; Peppler et al., 2016; Vuopala et al., 2020; Willett, 2017), can contribute to providing people with a sound knowledge base about media and technology. People can then use this base to develop their critical and reflective attitude towards media and technology (Buckingham, 2018; Knaus, 2020b; Niesyto & Moser, 2018). This in turn empowers them to tap into the social, economic and ecological structures and conditions with which media and technology are closely intertwined (Bijker, 2010; Brinda et al., 2020).

It is probably too early to say how approaches such as making might contribute to the challenges outlined above. But it is beyond doubt that for the digital transformation to truly contribute to the democratization of technology, it will be necessary for society to go through processes of cultivation and normalization and for individuals to go through processes of education. But as things stand, these processes are still in their infancy. It is because of these deficits that the spaces opened up by advances in technology are primarily being used by

only a handful of companies, whose power and influence therefore continue to grow (Knaus, 2020b).

Taking into account current developments in media and technology, this article will show that *tinkering*, *computational thinking*, *coding, physical computing* and *making* are approaches which can feasibly broaden the established dimensions of media literacy.

The creative design of media and technology as a cultural practice

To an ever-greater extent we view the world through a *media* prism; participatory media are making it possible for people to engage extensively in productive media practice (Buckingham, 2007). As a consequence, human communication and collaboration are increasingly taking place through a media conduit (Knaus, 2020a, pp. 28–33) – this all the more so in times of lockdowns and social distancing, although this was also the case before the pandemic (Knaus et al., 2021; Knaus et al., 2022). *Digital* media and their underlying technical and technological architecture are deepening the interfaces between people and machines. And because of these new interfaces, people are enabled to not only produce media artifacts, but also to create the applications as well as the underlying technical architecture of digital media (Bijker, 2010; Knaus, 2020a) – this turns them into technically empowered subjects (Knaus, 2020a, pp. 33–37; Knaus, 2020c). What is meant by technical empowerment exactly and how it differs from *media* empowerment, and what new scope for action this opens up for us and for our society will be described in greater detail in the following.

Whilst the cultural significance of media has already been subjected to wide-ranging interdisciplinary scrutiny and has advanced to become an educational objective, the humanities and social sciences have yet to devote sufficient attention to the significance of technology. The educational sciences in particular have yet to reflect upon the social and cultural significance of technological developments – to date, this work has largely been left to the engineering sciences and the technical disciplines (Knaus, 2017; Knaus, 2018a; Knaus, 2020b). However, if not only people but also technological principles and technology are exerting an influence on forms of representation, media artifacts and media devices, it soon becomes clear why people require media literacy to reflect on the latest developments in technology. The constructivist Siegfried J. Schmidt clearly shared this view when he said two decades ago that "mediapedagogical considerations […] cannot be limited to the way people handle the media available to them, they also need to devote sufficient attention to technical and media components and social-systematic components" (Schmidt, 2000, p. 150). In essence, we have only been *using* media, albeit often actively and creatively, but far too often we have been happy to leave the thinking about it to others (Knaus, 2020a, pp. 46–48). Or to use an even clearer formulation: Whoever performs the modeling (of the domains and architecture models) and encodes them determines what the world of tomorrow will look like (Cox, 2012; Knaus, 2020a; Manovich, 2008).

Ultimately, the goal is not to leave the future development of technology to trained technicians alone, but to enable all people to participate in it (Blikstein, 2013; Bijker, 2010): Do IT yourself! However, this means approaching technology less with the rational planning of an engineer and more in the spirit of creative experimentation and trial-and-error of a bricoleur (Duymedjian & Rueling, 2010): whilst the engineer's focus is on technical and scientific principles and knowledge, the bricoleur's approach is simply to use what is at hand.[1] Most helpfully, the French ethnologist Claude Lévi-Strauss has already discussed the differences between the engineer and the bricoleur in his work *La pensée sauvage* (Lévi-Strauss, 1962).

This differentiation is critical for establishing a clear understanding of *Maker Culture*, because it stresses the creative and playful elements of repurposing and experimentation with available resources and tools which anyone may use to innovate or broaden their mind. In other words, it is here that the learning process begins. The goal is therefore to *understand* current developmental trends in technology (and in particular in IT) and to empower people to take part in the discourse. Turning the creative design of media *and* technology into a new cultural practice is the first step towards establishing a fundamental understanding of media and technology (Knaus, 2020c; Knaus & Niesyto, 2019; Wing, 2006). This knowledge coupled with the first positive experiences of designing media are highly significant for people's further education and socialization; they are also the prerequisite for understanding that the world should not simply be taken for what it is, but that it can also be shaped and

[1] Incidentally, the archetypal bricoleur is the eponymous hero of the US television series Angus MacGyver.

influenced. It would of course be desirable to be able to look forward to the current processes of social transformation – the *digital transformation* – neither euphorically as a utopian dream, nor disconsolately as a dystopian one, but to see it as a task that requires our input, and as an opportunity to participate in change.

A fundamental understanding of technology, IT processes, data, and media advances to become a key educational goal. This is because only those people who are also in possession of the knowledge regarding what goes on behind the user interface have the competence to comprehend, decode, analyze, reflect upon and make a judgement about it (Knaus, 2020b). Only those who can understand the technological structure *behind* the (digital) medium can understand the medium as a whole (Knaus, 2020a). As a consequence, a conceptual understanding of technology and media and the ability to engage in critical reflection about media and technology become the founding stone for social empowerment and personal responsibility in a world which is to a considerable degree shaped by digital and networked media.

New opportunities for human-machine interaction

In view of the significance of digital media and technology for our societies, it not only makes sense to devote our attention to them at the technical (and economic) level, but also to give special consideration to their cultural, social and political implications. After all, it is not only the case that media and technology are the initiators of change for individuals and society; individuals and society also change technology (Bijker, 2010; Stalder, 2018). Or to phrase this differently: technical and media artifacts are not created in a social vacuum, they always exist in a social context (Brinda et al., 2020). If the world is largely shaped by media, then a central role must be given to the formation of the subject and the provision of social empowerment (Schorb, 2009) through the *action-oriented appropriation* of media artifacts (Baacke, 1996; Hurrelmann, 2002). Action is understood as something intentionally chosen by *human* agents as a way to achieve their goals. Accordingly, the *socially empowered subject* is a key element and a central normative idea of media education (Hurrelmann, 2002; Knaus et al., 2017; Tulodziecki, 2018; Tulodziecki, 2021).

The socially empowered subject is a concept which is particularly versatile and useful, especially in these times of digital transformation and not least in light of the broadened scope for action that digital media and technology offer with respect to creative design and active manipulation.[2] This is because social empowerment exists for a subject when they have at least some potentials to be a designer themselves – at the very least the freedom to design something lies in their active selection of media for consumption. Strictly speaking – and this also shows the complexity of the term "media consumption" – it is the case that *active* appropriation is any media reception, because what we hear and see must always be processed through our thoughts and actions (Froehlich, 1982; Schorb, 2009; Knaus & Bohnet, 2019). But above and beyond media reception, it is a person's autonomous actions in their media use that requires them to engage with the medium and its conditions in a critical and reflective way (Baacke, 1996; Dewey, 1950): In this light, Bernd Schorb (1998) understands empowerment in the context of media literacy acquisition as a person's ability to "use media autonomously and also to achieve technical mastery over them[,] and social and creative interaction ultimately as the ability to design their media use – as a form of communicative social action – creatively and imaginatively" (p. 7).

Since digital media are now ever-present in our lives, they are not only influential for people's personality development, they also have the potential to shape culture and society because individuals are now at liberty to actively and creatively design them (Bijker, 2010; Knaus, 2020a; Knaus, 2020c). The subject's claim to social empowerment therefore persists – especially with regard to media literacy. However, social contexts and their associated cultural technologies frequently undergo change not least because of changes and developments in media themselves. In a digital world, however, people are only socially empowered if they are able to engage in critical reception and make judgments, if they possess the necessary background knowledge, and if they are in a position not only to interact productively with media, but also to interact productively with technology behind the medium

[2] The meaning of the term manipulation as used in the text should not be confused with the similarly-connotated specialist term used in sociology or psychology. Neither does it mean that media are "manipulative". Manipulation as it is used here should be understood in its literal sense: *manus* is the Latin word for hand and *plere* means to fill. Manipulation might therefore be translated as "having things in your hand". Its intended meaning is therefore that we are not just aware of media and digital artifacts as recipients, but that we can also actively and creatively shape them with our *own* hands.

(Knaus, 2017; Knaus, 2020a). In this sense, the issue of social empowerment must always be addressed with one eye on the continually changing social context as well as the cultural technologies that make up society (Stalder, 2018; Brinda et al. 2020).

EXPERIENCE AND REFLECTION IN MEDIA EDUCATION

This article's defense of *maker education* is constructed upon an action-oriented theoretical analysis of the *human-medium-machine interaction* (Knaus, 2020a): the analysis clearly reveals that especially *digital* media and technology are opening up new discourse potentials and broadening the opportunities for participation. This is thanks to their conceptual principles of binarity, automation, programmability and algorithmicity, interconnectedness and referentiality as well as the meta-processes mediatization and digitization (Knaus, 2020a). The varying "depths" of interaction between human, medium and machine serve as the starting point for discussion.

Human, medium, and machine: A model of interaction

The following discussion builds upon the conceptual groundwork mentioned above which positions the new potential for action offered by media and technology at the interface between human, medium and machine, and which was inspired by the Open Systems Interconnection Model (Knaus, 2020a). The model consists of three technical levels: the hardware as a physical basis, the application level and the media user interface of the machine. The medium is the central interface between the human and the machine: the symbols that the machine outputs have meaning ascribed to them by human interpretation; in turn, the human being can use the media interface to step in and control the machine. The medium as the point at which human and machine interact therefore represents on the one hand the inter*face*, so to speak the "face of the machine", and on the other hand it represents the opportunity to engage in participatory procedures (Knaus, 2020a, p. 27)

The interaction model describes four modes of interaction. The following text summarizes the key findings from each of the individual levels of interaction following an analysis from the perspective of educational science.

The first mode of interaction is *receptive media practice*: here, media artifacts and their representations are not just "received" but are, on the basis of the personal and social experiences of the individual, always (comprehendingly) converted into thoughts and actions (Baacke, 1996; Froehlich, 1982; Schorb, 2009; Knaus & Bohnet, 2019). The educational goal which derives from this mode is that ideally all individuals in society are given the opportunity to transform themselves into critical recipients. Whilst this postulation is not new in the history of critical media literacy (Buckingham, 2018; Knaus, 2020b; Niesyto & Moser, 2018), the existence of ever-greater numbers of information sources, the commercialization of attentional control in information searches and in social networks, and even totalitarian forms of data collection and monitoring, make this goal more relevant than ever (Beer, 2019; Knaus, 2020b).

The second mode of interaction addresses *productive media practice*: this deals with creativity and design in media practice – that is, the active human exertion of influence on the medium. Productive media practice – the production and distribution of media artifacts – is potentially open to anybody thanks to digital devices and social media – so-called participatory media. This means that everybody can actively produce, develop, modify and disseminate media artifacts. In this way, the technical network – the Internet – and digital media not only help to overcome spatial and temporal limits in information and communication processes and hence shift the traditional coordinates of media articulation, they also make it possible to slowly but surely dissolve the traditional boundaries between media reception and media production (Biermann et al., 2014). Until now, people without technical expertise have been unable to exert any significant influence on the machine beyond what was possible through its media (user) interface. Social empowerment with respect to media and technology were considered to be "complete" when people were able to act proficiently on the two previously mentioned levels – receptive and productive *media* practice. This is also revealed in well-established traditional (e.g. Baacke, 1996) as well as more recent media literacy models (e.g. Redecker & Punie, 2017).

The third mode of interaction – *productive technical practice on the application level* – goes somewhat "deeper" and includes the question of how to interact with software and applications (Knaus, 2017). Thanks to the programmability of digital media (Manovich, 2008), people are in a position to alter software codes and applications. This scope for altering the application level

of digital media means that potentially anybody has the means to engage in technical manipulation and in doing so to become a productive technical practitioner. The fourth mode of interaction involves far greater influence being exerted on the machine: *productive technical practice at the hardware level*. This means that it is also possible for the user to influence the technology itself – and no longer just through the media (user) interface or software. Outcomes from this mode of interaction show that people can creatively design not only the media artifacts and applications, but also increasingly the "hardware" of the machine and that they do this by developing their own tools or by modifying existing technical artifacts (Knaus & Schmidt, 2020). It is at precisely this level that *making* becomes relevant.

Doing and experience

The following analysis seeks to show that the development of media and technology in society presents a challenge not only for educational institutions and entities which are influential for human socialization, it also opens up new approaches to teaching and learning with and about media as well as teaching and learning with and about technology. One of the foremost challenges for education in a world increasingly impacted by mediatization and the digital transformation is to provide learners with a mastery of digital media, tools and technology for their own goals and needs and their reflections about themselves, and about media and society (Knaus, 2020a).

However, because *digital* media have become ever-more integrated into everyday human communication (e.g. Baecker, 2007; Hepp, 2020; Hobbs, 2011), the concentration should not only be on users' *use* of media, but – in addition to providing a point of entry to the world – should actually be on offering people access to it to give them the opportunity to actively design their world around them. It is necessary to precisely have such points of entry and active access to the world in order to gather experience, and herein lies one of the key aspects of the action-oriented approach of making: John Dewey's experiential learning, in which experience is key, is one of the cornerstones of the action-oriented approach of making in media education. In non-academic contexts, people often think of John Dewey's educational theory simply along the lines of "doing" in the sense of *learning by doing*, while the learner's subsequent process of *reflection* about what they have experienced through their actions is frequently overlooked – this is one of the reasons why making is not always synonymous with *pedagogical* making.

Of particular interest for the action-oriented approach are processes which take place in an agent's so-called secondary experience: Whilst primary experience encompasses situations in which an agent behaves habitually and does not reflect upon their actions, the second mode of experience is when situations arise which an agent cannot deal with based on their existing experience. The agent is forced to reflect upon and think about how to deal with the situation at hand – the medium, the media or technical artifact – and explore its meanings and implications. A makerspace can provide individuals with the necessary material and social environment for the process of reflection they engage in about how they interact with digital media, and can therefore open up new opportunities for education. The makerspace therefore becomes an all-encompassing experiential space in which primary experience serves as the foundation for broadening secondary experience. This facilitates the kind of spectrum of competence encompassing the interaction between media, subject and society as envisaged by media education and its objective of achieving media literacy – a concept which, in the light of current developments in media, technology and society, now requires revision.

Media literacy and making

Media literacy is the key objective of media education (e.g. Buckingham, 2003; Hobbs, 2011). The concept of media literacy acquired its original definition in no small measure thanks to the work of Dieter Baacke (e.g. 1973 and 1996). In his work, Baacke sees media literacy as the foremost skill which individuals must acquire, as it constitutes the basis for acquiring a solid understanding of media-based communication and interaction (Baacke, 1996). Over the last three decades, the concept has been developed further, adapted to accommodate new technological and social developments, and refined (e.g. Buckingham, 2003; Hobbs, 2011; Knaus, 2020b; Moser et al., 2011; Treumann et al., 2002). Media literacy is constructed upon communicative competence (Chomsky, 1968; Habermas, 1981) and seeks to empower media users to deal confidently with the opportunities presented to them by media and feel comfortable operating in a media-centric world – Dieter Baacke speaks in this

context of media empowerment.[3] Baacke's widely-cited classic model of media literacy divides media empowerment ["medienbezogene Handlungskompetenz"] into four dimensions: media knowledge ["Medienkunde"], critical media literacy ["Medienkritik"], media use ["Mediennutzung"] and media creation ["Mediengestaltung"].

How might these dimensions of media literacy be broadened if – as set out here – the future world is not just media-based but also *digital* (Buckingham, 2007; Hobbs, 2011; Knaus, 2020c; Sefton-Green et al., 2009), a world in which omnipresent media using digital technology open up not only media-related but also *technical* possibilities to us? What happens, with the machine as our co-communicator (Baecker, 2007), if we require technical empowerment in addition to media empowerment for our interaction? Figure 1 depicts a draft design which broadens the classic parameters of media literacy by adding the new approaches to it. The points and sub-points which are included in the classic concept of media literacy, and how this can be expanded upon by the aforementioned elements, will be explained in brief in the following.

Figure 1. *Dimensions of media literacy in the digital age*

The *critical media literacy* dimension encompasses a person's ability to understand social processes analytically and to use their newly-acquired knowledge to engage in self-reflection and apply their knowledge to their own actions (Baacke, 1996; Buckingham, 2018). The ethical sub-dimension of critical media literacy includes back-referencing one's analytical thinking and reflections to one's own sense of responsibility towards society and one's fellow human beings (Baacke, 1996). In order to be able to critically question media developments and social processes, it is essential to have a sound knowledge of media structures and possess the relevant background knowledge.

Tinkering might entail testing software and hardware to its limits. This gives rise to processes of reflection which can trigger critical engagement with the functionalities, processes and boundaries of media and technology. Tinkering can therefore be understood as an action-oriented and technology-based form of critical media literacy (Knaus & Schmidt, 2020). In using the term *critical digital literacy* – and this is equally the case for critical media literacy – the term "criticism" should not be understood by its everyday meaning of rejection, unfounded hostility or fear of media and technology (including media systems and institutions), but in the sense of an analytical and reflective engagement with these areas and developments. This kind of engagement is potentially – as tinkering shows – not only rational and cognitive, but also action-oriented and even playful or creative (Knaus & Niesyto, 2019; Knaus & Schmidt, 2020; Zierer 2021).

The *media knowledge* dimension was originally used to refer to knowledge *about* media. Media knowledge is subdivided into an informative dimension and an instrumental qualification-based dimension (Baacke, 1996). Whilst the first sub-dimension encompasses classic knowledge inventories such as everyday knowledge or area-specific specialist knowledge, the second sub-dimension encompasses knowledge or facts with a practical application (Baacke, 1996, p. 99).

If – as described above – media increasingly rely on the technological architecture which allows the technology to participate in human communication, then future users will not only have to be equipped with media knowledge, but also at the very least a basic knowledge of technology. Here lies the intersection between media literacy on the one hand and technology literacy education and informatics education on the

[3] One of the first thoughts devoted to activating and involving the public in media can be traced back to Bertolt Brecht's *Radiotheorie* in the 1930s: Brecht proposed developing the radio from a receptive device into a *communication* device in order to liberate the listeners from their position as consumers and to give them a voice of their own (Brecht, 1967). A number of years later, Hans Magnus Enzensberger also called for the activation of the passive media public by involving them actively in the production of media (Enzensberger, 1970). It was no coincidence that the heyday of action-oriented media education was during the time when amateur media were establishing themselves (Engel, 2010) alongside professional mass media such as printing, radio and television. Action-oriented media education was founded as a result of the advent of audiovisual media, such as the video camera which not only used simplified home-grown media production in comparison to traditional film cameras, but made it accessible to amateurs. Since then, it has been possible for everybody – at least in principle – to participate in media production.

other (Knaus, 2017). One possible approach to fostering technology literacy is *computational thinking* (Wing, 2006). This approach broadens users' knowledge to encompass IT content – it describes a user's ability to formulate potential solutions to problems in such a way that they can be understood and implemented by human beings and machines alike. To do this, human beings have to adopt the machine's abstract mode of operation in order to comprehend and understand its "mindset". This process can serve to clarify technological principles. This approach therefore goes beyond the simple learning of purely factual knowledge and includes action-oriented forms of knowledge – as is already the case with the traditional instrumental qualification-based sub-dimension of media knowledge (Baacke, 1996).

According to Dieter Baacke (1996), the *media use* dimension encompasses the skills required to engage with and use media. Media use is sub-divided into the two skills categories *reception and use* and *interaction*, and was originally used to refer to the (participatory) medium but changed considerably as a consequence of the media transformation described above. The media use dimension experienced contentual change primarily in the course of the digital transformation and the change to *productive technical practice* described above, because potential human uses for media were no longer limited to the medium. It was in this context that the concept of the tool experienced something of a renaissance, because media artifacts were no longer simply objects to look at, but could be manipulated with the help of digital tools (Schelhowe, 1997; Knaus, 2020b). This foray into the world of creativity tested the boundaries of how we understand the meaning of *use*, because using a medium or a technical device always implies remaining within and acting within the parameters laid down by its designer or the programmer. Using a media or technical artifact therefore always implies that the user occupies a subordinate position in an existing structure.

The fourth dimension, that of *media creation*, sees the "user" liberating themselves from this subordinate position to the designer: Even the traditional definition of creating and manipulating media conceives of it as being something aesthetically creative as well as innovative – in the sense of taking an existing medium and subjecting it to further development (Baacke, 1996; Buckingham, 2007; Hertz, 2015; Schelhowe, 1997). This results in new artifacts and new forms of representation and media; humans (formerly known as "users") become productive media practitioners. One very well-known and established approach to fostering aesthetically-creative and innovative media practice in educational contexts both inside and outside school is *active media work*. This approach motivates the (original) user to work with media independently and to use them as a means of expression – as a means of communication and interaction (Schell, 1989).

Baacke's aesthetically-creative and innovative *media creation* approach can be broadened in the sense of *creative technical practice 1* at the software level to include *coding*. In a similar way to active media work, coding enables the media user to identify how to exert influence on a machine at the application level. Media education, in seeking to identify how influential media are (what do media do to people?), has taken the question one step further to encompass the active constructivist subject, asking what can people do with machines? In doing this, coding represents the first broadening of the question to include *technical* aspects: What can people do with technology at the applications level? Furthermore, creating and manipulating media can also be expanded in the sense of *productive technical practice 2* at the hardware level in the form of *physical computing* or *making*.

The key element of *making* is autonomous action: the re-invention or modification of things. The question of what people can do with media and technology is therefore broadened to include hardware – and hence the machine in its entirety. After all, the maker movement relies on the idea that individuals only truly appropriate things when they not merely use them but are also capable of taking them apart and rebuilding them. This belief clearly shows that one of the driving ideas behind the maker movement is that it stakes a democratic claim to technology, tools and media (at the same time revealing the boundaries of productive technical practice) which exist in encased and sealed hardware (as is the case with many smartphones and tablets) or tightly regulated development environments and distribution concepts. Further characteristics of the movement include multi-generational collaboration and the creation of communal spaces (e.g. Willett, 2017), whereby a space does not necessarily have to be a physical space.

So what active media work offers the media creation dimension, coding and making offer the creative and innovative design of media and technology, broadened to include digital technology. These approaches therefore serve to broadly promote users' critical, distancing and reflective skills from the mode of production with respect to media and its underlying

technology (Hertz, 2015; Knaus, 2017; Tulodziecki, 2021). This then completes the circle which started with autonomous action – of (media/technical) design – and the user's reflection on their actions, resulting in critical media literacy and critical digital literacy.[4]

MAKING AS AN EDUCATIONAL OPPORTUNITY

After having examined the theories and concepts underlying the educational relevance which critical digital literacy, tinkering, technology literacy, computational thinking, tool use, coding, physical computing and making have for a form of media literacy education which includes learning about media *and* technology, the discussion now turns its attention to schools and universities, the institutions whose task it is to put these theories and concepts into practice.

Makerspaces in schools

The relevance of media literacy education, technology literacy education and informatics education can be summarized in three arguments: The first argument is that it is part of everyday life; young people are growing up in a society which is fundamentally shaped by media as well as technological influences. School as an educational institution is therefore tasked with accommodating these social developments and everyday lifeworld experiences – not least in order to give adolescents a sense of orientation in a society which is highly challenging for them (Doebeli Honegger, 2017; Herzig, 2020; Knaus, 2017b). The second argument relates to innovation and productivity. This underscores the significance of digital media in social fields such as science, research, industry, trade, services and culture. By engaging with mediatization and the digital transformation, school should constitute a platform for ensuring that future generations secure productivity and the capacity for innovation (Andersen, 2020; Doebeli Honegger, 2017; Herzig, 2020). The third argument relates to education and personality development. This argument exposes the limitations of a functional-instrumental understanding of education and proposes using a critical and reflective approach to media and technology to encourage participation and empowerment; these in turn support the identity formation process (Herzig, 2020; Knaus, 2017b).

Approaches which bring together life-world arguments, productivity-related arguments and aspects of personality development play a role in all types of schools and school grades; it is only the point of departure that differs: Whilst primary school maker education tends to focus on the process of "making things"– such as constructing objects out of various materials – secondary schools tend to stress cognitive processes – such as understanding and reflecting on *making* (Halverson & Sheridan, 2014). The following examples are intended to show that whilst autonomous actions and reflection upon them are weighted differently in different contexts, the aspect of experiencing something and engaging in a process of learning through reflection about that experience is always a fundamental constituent element of all educational making projects.

Let us take a simple practical example for primary school by way of illustration. It shows how tinkering, coding and making can be combined: The students are asked to build a small robot which can track and move along a black line on a large piece of paper. This requires them to discuss how sensors function, to examine what powers the bot, and enables them to explore the program code to understand why the robot behaves the way it does. If the children are left to experiment further on the robot, they often draw the lines closer and closer together on the paper until the robot reaches the limits of its capability and stops working or falls over. This example shows that *tinkering* comes naturally to children; this opens up manifold opportunities to use their experiences as a child-friendly way of looking into further media-related and technological topics in the classroom (Knaus & Schmidt, 2020). If the children have not built the robots themselves, it will probably not be long before they start to take them apart to see what is inside them, what is powering them and how they function (Knaus & Niesyto, 2019).

Makerspaces in universities

Makerspaces in universities – as well as in established *media centers* in universities – basically exist to fulfill three tasks: First, they are places that

[4] The dividing lines between the dimensions and approaches are not always clear-cut. Indeed, they tend to be quite fluid. Here, for example, *computational thinking* was placed in the dimension of media knowledge, but it also addresses aspects which belong to the dimensions of critical media literacy or critical digital literacy, as well as media use.

provide users with access to media, devices and tools which are otherwise not necessarily available to private individuals. Second, they are – in parallel to centers for higher education teaching – the destination of choice for advice on media-based teaching and subject-specific teaching methodologies. Thanks to the advisory service they offer and the equipment they have available to them, they also fulfill the task of transforming media and technology-related developments into a shared experience: Lecturers and students alike can use media centers to create their own media products, and in doing so learn how to reflect upon how they handle different forms of representation, media artifacts and media devices. They can also experience first-hand the background and practice of the media system and in doing so ultimately acquire their own media literacy. Makerspaces are therefore – just like media centers themselves – inspiring places which encourage people to engage in collaborative making, experience and reflection; they broaden users' access to media with their (wide range of) tools, which can be used to create and manipulate not only media but also applications and hardware. This enables them to enhance users' media literacy, even in its broader sense encompassing digital literacy. Media centers and makerspaces at higher education teacher-training facilities have an additional, fourth task: They must not only enable trainee teachers to improve their *own* media literacy, they must give them the skills which qualify them to promote the media literacy of their students. This presupposes that the trainee teachers have ideally already experienced the above-mentioned courses and projects themselves, so that they can use them in their own classes to support their students in the future.

Whilst university media centers are equipped well enough to work productively with media, their technical facilities and their levels of specialist expertise for promoting productive technical practice remain limited (at least outside the laboratories in the technical faculties, which are not available for all students and lecturers to use). Makerspaces are therefore being established at a number of universities. In some cases, makerspaces are being used to complement the media center or – if the makerspace is located in the media center – to broaden its range of services: Where required, lecturers and students can access technical equipment which is not (yet) available to everybody, but also receive aesthetic or action-oriented support and guidance through the media and technology production process.

The above discussion reveals that makerspaces are not simply a new term for media centers, but a further step forwards in their development: Due to the technical media developments outlined above, numerous media tools such as high-resolution video cameras or editing software, which not everybody had access to until just a few years ago, are now either installed in smartphones or available as an app for a small charge. In order to produce a video clip and edit it, it is no longer necessary to borrow a technical device from a media center. It is for this reason that media centers are developing into places that provide multiple points of access to media devices, into places of collaborative learning – where people meet and share their experiences. The change in the form and content of the media center into an educational makerspace (with its associated broadening of the *media* concept) arises out of the rationale set out in this article, which argues in favor of a more all-encompassing definition of media literacy. At its core, this definition continues to denote the making of products using new technology, with active participants seeking advice and sharing experiences with each other, but it is no longer just media that are being produced or modified, it is also technical artifacts such as apps, software or websites (*coding*), hardware, like bots, toys, mini-computers or electronic tools (*physical computing* and *educational making*). Media centers and makerspaces therefore intersect, with both providing access to (media) technology, to collaborative making and to the sharing of experience.

CONCLUSION

The approaches outlined above meet essential educational objectives. But the use of digital media and technology – as demonstrated by action-oriented learning theory – also offers potential new approaches to teaching in schools (Aufenanger et al., 2017; Vuopala et al., 2020; Ingold & Maurer 2021), universities (Macgilchrist et al., 2020; Knaus & Schmidt, 2020) and in informal spaces (Meyers et al., 2013; Willett, 2017). This is because learner-activating, experience-based and action-oriented approaches result in more sustainable learning than teaching methods based purely on receptive and cognitive stimulation and engagement with learning content. The digital transformation has had a profound effect on communication and interaction, and has broadened traditional cultural technologies (e.g. Andersen, 2020; Stalder, 2018). As a consequence, it is imperative to enhance the communicative and participatory capacities of all people

irrespective of their educational stratum in society. This means – to cite a classic normative guiding principle (Hurrelmann, 2002; Tulodziecki, 2021) – nothing less than raising their level of *social empowerment* ["gesellschaftliche Handlungsfähigkeit"].

To conclude my discussion and by way of an example, I would briefly like to present an externally-funded project currently in progress under the aegis of the Professional School of Education Stuttgart-Ludwigsburg (PSE) in Germany: In line with the proposed broadening of the traditional dimensions of media literacy to include technical and design-oriented aspects and so-called "digital competences" (e.g. Redecker & Punie, 2017), educational makerspaces are being set up by the project *MakEd_digital* (funded by the Federal Ministry of Education and Research; support code: 01JA2026B). Given that teachers are key multipliers for promoting digital literacy, the project aims to establish educational makerspaces for the teacher training programs at five universities.

These makerspaces, conceived of as open workshops, add to the range of services on offer at the media centers by including educational approaches to digitization, and are intended to give students (and especially future teachers) the chance to develop media-related and digital teaching plans and materials in a creative and open environment. The project seeks to increase the students' competence-levels in Media Education, Technical Education and Informatics Education, and evaluate them using educational design research (McKenney & Reeves, 2018). The project team has chosen this approach with the aim of acquiring a better understanding of *digital literacy* and studying how it may be adapted for practical use in the classroom context.

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