CLARIFYING THE EFFECTS OF DIGITALIZATION ON (HIGHER) EDUCATION

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Abstract

Digitalization, i.e. the comprehensive application of digital technologies on numerous data, affects and changes our lives in various ways. Education, and in particular higher education, needs to respond to the challenges due to these changes in various ways. Unfortunately, there is hardly any systematic research into what the effects of digitalization on higher education actually are, let alone what needs to be done to cope with these effects.

This paper discusses four major challenges, namely new types of students entering universities (Generations Y/Z), future skills as potential learning outcomes of higher education, new didactical approaches and tools due to and based on digitalization, and the need to put instructors as "digital immigrants" into a position to cope with digitalization. As a step in responding to these challenges, the paper presents a research design to address each of these challenges.

Digitalization leads to such a huge amount of disruptive changes, affecting a multitude of parameters simultaneously, that there is no understanding yet which aspects are influenced in which way. A systematic and sound scientific research approach is proposed in this paper which is a prerequisite for being able to develop modern and adequate educational approaches which enable societies to cope with challenges of digitalization.

Keywords: Digitalization; higher education; future skills; Generation Y/Z.

1 DIGITALIZATION AS A MEGATREND

Digitalization is a process that passed through several stages of digital disruptions [1]: Digitalization began with the advent of digital computers in the 1950s and the rise of the internet in the 1990s. In the 2010s, digitalization gained momentum with the widespread use of social media, mobile devices, cloud computing, and data analytics, currently supplemented by such techniques as artificial intelligence, robotics, and natural language processing. As a result, all areas of our lives are undergoing massive changes: in the professional sector, production is getting increasingly smarter by relying on autonomous and communicating machinery (Industry 4.0) [2], in everyday life, traditionally "dumb" devices such as refrigerators or window blinds are getting increasingly intelligent and interwoven with each other (Internet of Things). Since neither our professional, nor our private lives can be excepted from these transformations, it comes as no surprise that education also needs to undergo massive changes [3]: digitalization offers new tools that can be used in education, but also learners change in terms of learning habits and digital literacy.

Although there are some efforts to better understand what these changes might be in primary or secondary education, it is, at best, only vaguely know how digitalization affects higher education. This is particularly unclear in disciplines that are complex even now, with growing complexity through digitalization. Software engineering is one of these disciplines: since this facet of informatics is concerned with the systematic construction of large and complex software systems, software engineering education will have to pay tribute to new technologies, new application areas, and new types of users in these systems due to digitalization. At the same time, students will change, and so will educational tools.

This paper attempts to make a case for better understanding the effects of digitalization on higher education, highlights areas that need to be examined thoroughly in order to arrive at such a better understanding, and presents a research agenda and research design.

2 DEFINITION OF TERMS

The terms “digitalization” and “digitization” are often used interchangeably. Nevertheless, there is a clear distinction: digitization is concerned with "converting and / or representing analog / physical...
things into a digital format”. In contrast, digitalization “is the application of digital technologies and data (digitized and natively digital) in order to create business value and generate revenue, improve businesses and/or society, replace and transform processes and create an environment for digital economy and digital society, whereby digital information is at the core” [4]. In particular, digitalization means that, at the micro level, individual components or devices become somewhat intelligent in that they are able to capture data through sensors and affect their environment through actors. At the same time, at the macro level, systems get increasingly complex by gluing together micro level components (or sub-systems) in novel ways, thus leading to intricate relationships between embedded components.

As a side effect, digitalization comes along with huge amounts of data that pose new challenges in itself, but offer new opportunities for in-depth analyses. In particular, large volumes of data that come in different formats (variety) and need to be processed in real-time (velocity), although they might be partially faulty (veracity) are often called big data [5]. This established a specific field of interest, namely learning analytics, which aims at analysing data that originate in learning processes.

3 HIGHER EDUCATION IN CONTEXT OF DIGITALIZATION

An established, though somewhat simplistic model in didactics is the so-called didactic triangle (see Fig. 1) which expresses that three fundamental components, namely learner, instructor, and content interact in any didactical setting [6]. Although this model has been criticized for neglecting the complex interactions between educational goals, content, and methods for teaching and learning, it is still helpful to highlight four categories that are relevant for any didactical consideration: Learners (i.e. students in higher education), content, instructors, and didactical approaches as a link between the three.

A core element in educational processes are human beings which learn and train their competences. Well established educational theories, e.g. the Berlin or Hamburg models of education [7] or Klafki’s didactic analysis [8, 9], are holistic in the sense that they are neither exclusively instructor- or learner-centric, nor primarily focussed on methods or content. Taking the needs of learners into account is particularly important in higher education: students are the essential factor in higher education and a prerequisite for universities. Students have a strong influence on learning settings as they bring in their mind-sets and characteristic ways of learning. Consequently, learning settings have to be adapted to students’ needs. Didactical decisions concerning, e.g., content, methods, or media ought to be based on students’ learning behaviour.
Higher education aims at training competences. Competences comprise technical expertise as well as context-sensitive non-technical skills and generic soft skills [10]. Since digitalization changes students' learning behaviour and, consequently, learning settings, learning goals and intended learning outcomes also have to be adapted to the new digitalized world. In particular, it is not sufficient for higher education to only address technical expertise in a specific field, but rather higher education must address and support the development of so-called future skills.

Once goals change, so do the methods to reach these goals. In particular, changing intended learning outcomes (e.g. due to the need to prepare learners for digitalization issues) entail new educational concepts for reaching them.

Instructors need to put these new educational concepts in action, but also need to be prepared for doing so. More specifically, implementing advanced educational concepts may require competences that instructors have never been trained for, e.g. simply due to the fact that a multitude of digital means have only been used in educational settings recently since they had not been around a couple of years ago.

We argue that digitalization gives rise to need for further research in each of these four categories. In the following, we discuss each of the four categories in more detail.

3.1 Students – A New Generation

In the last few years, so-called digital natives entered their working life by starting an apprenticeship or enrolling in a university program. Born after 2000, these students grew up amidst digital media. Digital natives "is a term for individuals who have grown up around technology, appear comfortable with it, and benefit from what it has to offer." (11, p. 205) The so-called Generations Y or Z [12] cannot imagine a world without internet, Instagram, Wikipedia, or cell phone. They are always online and do nearly everything in a digital way. For instance, this generation of students refrains from using "classical" books as a medium for learning, but rather use digital media such as (digital) learning videos (see, e.g., [13]).

Using digital media all the time has consequences on learning behaviour and psychological aspects of learning: Different kinds of experiences lead to different brain structures and different thinking patterns [14]. Today’s students think and process information in a fundamentally different way, compared to their predecessors [15]. This also affects educational processes. "There are fewer personal projects among the students, less autonomy and skepticism, less irony and a critical spirit." [16, p. 255] "Our students have changed radically. Today’s students are no longer the people our educational system was designed to teach." [15, p. 2]

3.2 Future Skills - A New Goal of Higher Education

Students of generation Y or Z not only bring in different competences and learning habits than earlier generations of students. Furthermore, other and new competences are required to learn in and deal with a digital world. This is because digitalization as a megatrend affects all aspects of daily life. Current graduates must deal with completely different problems and solutions than their predecessors had to do twenty years ago. Digitalization turned production processes into Industry 4.0 and analogue devices into the Internet of Things. These disruptive shifts reshape the workplaces [17]. Therefore, complexity of problems increases and requires new solutions. Graduates have to find their way to cope with these challenges. Problems are no longer caused only by multidisciplinarity and cannot be solved simply by training communication skills but rather require so-called future skills. To the same extent as „incoming“ competences in higher education change by Generation Y or Z, goals of higher education change as well. Future skills are competences which are needed in the future. Unfortunately, no research exists yet to clarify what future skills exactly include and how they should be understood. At the moment, only vague ideas exist (see e.g. [18], https://future-skills.net).

3.3 Didactics in Higher Education – New Possibilities

If students’ mind-sets and brain structures as well as learning goals of higher education change, learning processes most likely have to be adjusted, too. Digital natives “have little patience for lectures, step-by-step logic, and “tell-test” instruction.” [15, p. 4]

In higher education, various possibilities for supporting learning processes emerge due to digitalization:
• Contents and knowledge become accessible independent of time or place restrictions. Internet and search engines provide access to knowledge anywhere and anytime on earth. Cloud services and learning management systems allow distributing, sharing, and retaining information. As a result, learning processes can be supported easier than some years before. Education becomes accessible to more people and digitalization offers new ideas for fostering life-long and life-wide learning [19–21], e.g. by facilitating extra-occupational further education courses [22].

• Learning analytics and the possibility to collect, evaluate, and personalise big amounts of data facilitate learning by recommending next learning steps or learning media on an individualised basis [23]. Nevertheless, learning analytics must respect privacy and security issues [24].

• Micro-learning elements pay tribute to Generation Y/Z's requirements of short attention spans and offer knowledge bits in small-sized pieces. Repetitions support students in memorizing facts.

• Digitalization opens up new possibilities for assessment and examination.

3.4 Instructors in Higher Education – New Required Competences and Challenges

As described above, digitalization changes incoming students, learning processes and methods, and intended learning outcomes of educational systems. In addition, there is still a main aspect in education which affects learning processes in a massive way, but is often neglected: instructors. Instructors are predominantly “digital immigrants” [15] who learned to deal with digital media at a later point in their lives. Due to sticking with one foot in the past, digital immigrants always show a so-called “digital accent”. Prensky sees this accent e.g. “in needing to print out a document written on the computer in order to edit it (rather than just editing on the screen); and bringing people physically into your office to see an interesting website (rather than just sending them the URL)” [15, p. 3]. Instructors, in spite of being digital immigrants themselves, are now supposed to enable students to deal with digital media, information overflow, distinguishing useful or scientific data from simple unsubstantiated claims and hypotheses, etc. That is, instructors as digital immigrants shall provide learning settings for digital natives which support new intended learning outcomes in the form of future skills.

To aggravate things, instructors first have to “learn” applying and using digital media themselves [15] before developing medial didactical approaches for students. This requires broad training programs and further education offers for instructors. In contrast to teacher education for schools, no systematic trainings are offered for instructors at universities (see e.g. 25; 26, 27) so far.

3.5 Consequences for Higher Education

Digitalization as a megatrend causes disruptive changes which also affect educational system. Various new opportunities emerge, but currently many issues are hardly being investigated, let alone solved. Among the many currently unanswered questions are, e.g.:

With respect to “new generation of students”:

• What are suitable elements for micro-learning to accommodate Generation Y/Z? How and according to which strategy can tiny learning chunks, such as in micro-learning, be arranged to form a coherent big picture?

• How can learning analytics be successfully used to adapt learning settings to individual learning habits and needs of Generation Y/Z students, under due consideration of privacy and security issues? Which learning data are useful to draw conclusions on reasonable adaptations, e.g. by pinpointing individual learning obstacles?

With respect to “future skills”:

• What exactly are so-called future skills? How can they be identified? What is their precise meaning?

With respect to “didactic aspects of higher education”:

• If future skills are intended learning outcomes in higher education, how can they be addressed and evaluated?
• Can digitalization support the assessment of future skills? How far can digitalized assessment methods reach beyond plain knowledge?

With respect to “competences for instructors in higher education”:

• How does digitalization affect required competences of instructors in higher education?
• How can instructors in higher education be enabled to teach in the era of digitalization?
• “We are facing a world where the cost per bit of information is getting cheaper, while the cost of a useful bit may be exceedingly costly.” [15, p. 3]. But then, how can knowledge in a digitalized world be restricted to the essential bits?

4 METHODOLOGY

In order to find answers to some of these questions, we currently pursue several lines of research. Since students nowadays learn completely different than instructors did when they were students, new learning patterns must be detected and understood as a basis for developing learning settings and educate instructors. Consequently, concerning the “new generation of students” it is necessary to better understand how students of Generation Y/Z actually learn. Core element in this research step is analysing learning situations and learning habits of Generation Y/Z to better understand their ways and ideas of learning as a basis for future didactics. Since this is a complex research question with lots of unknown influences, research must develop a theory at first. To do so, a mixed method approach seems appropriate: On the one hand, some qualitative data must be collected and analysed in order to deduce criteria and factors which determine learning processes of Generation Y/Z students. On the other hand, in a next step, quantitative big data studies can highlight clusters in records of learning processes or typical learning concepts of Generation Y/Z students. These results can in turn be interpreted by qualitative approaches which allow to draw conclusions on ways of learning in Generation Y/Z.

Regarding “future skills”, we set up a qualitative research design based on Grounded Theory [28] to characterize future skills more precisely. This step encompasses qualitative interviews with different groups of persons. Practitioners, instructors, students, parents, school teachers, managers etc. will be asked for their idea of “future skills”. The interviews will be transcribed and analysed and, in a next step, and put in relation to job profiles. Results are future skill profiles for different jobs which can serve for deriving intended learning outcomes in vocational or higher education.

Concerning “didactic aspects of higher education”, a better understanding of how future skills can be addressed for Generation Y/Z students is necessary. Therefore, didactic theories have to be further developed and adapted so that a digitalization didactics can evolve. Once there is a clear picture of what higher education should be aiming at, this step will be directed towards competence-oriented learning settings that address (some of) these future skills in a suitable format for new generations of students (Y/Z) and, potentially, exploiting digital media and tools.

In particular, for the latter issue, we investigate, in parallel, learning videos in the context of software engineering education as a means to support self-directed learning for Generation Y/Z students [13]. In that respect, we work on developing a learning video platform that offers context-specific, individualized recommendations for learners which video might adequately help them to understand a specific issue, based on analysing data on learning obstacles.

After definition of intended learning outcomes and gaining a better understanding of learning processes concerning this special target group an evaluation tool is required which allows assessing the effects of didactical settings which address future skills. SECAT [29] can be an adequate basis and may be adapted to the evaluation of didactical settings addressing future skills.

Regarding “competences for instructors in higher education”, research results from the prior steps have to be continued, expanded, and combined in specific educational approaches for teachers and instructors. The implementation depends on several factors which cannot be specified precisely at this point in time.

5 EXPECTED RESULTS

In conclusion, this research results in …
• ... a deeper, better understanding of how Generation Y/Z students learn.
• ... a deeper, better understanding of the term future skills. There will be a rich, thick description [30, p. 942] of what can be understood by “future skills”. This is the basis for mapping the general term of future skills to specific situations in individual learning biographies on the one hand and to specific job profiles on the other hand. Each profession requires a different set of future skills.
• ... a sound theoretical basis which is a prerequisite for developing adequate and suitable didactical settings for Generation Y/Z students.
• ... a methodology for assessing future skills in different learning situations.
• ... systematic education approaches and train-the-trainer concepts for instructors on a scientific basis.

6 SUMMARY
Digitalization affects all areas of our daily and professional lives. Dealing with these changes that digitalization brings about poses many challenges for education in general and higher education in particular. Based on the didactic triangle, we focus our research on four areas of higher education, namely students, instructors, content, and didactics. For each of these areas, we highlight several research questions and developed research designs to tackle these questions.

In summary, we argue that digitalization leads to a multitude of disruptive changes. As a consequence, a huge number of parameters is affected simultaneously such that there is no understanding yet which aspects are affected by digitalization in which way. In our opinion, it is inevitable to research these effects systematically and on a sound scientific basis since this is a prerequisite for being able to develop modern and adequate educational approaches which enable societies to cope with challenges of digitalization.

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