



Digitization bolstering self-directed learning for information literate adults—A systematic review

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ABSTRACT

Learning skills are fundamental 21st century skills that enable people to thrive in an increasingly uncertain future. Digitization and the current COVID-19 pandemic have been key drivers of uncertainty and changing conditions. In the face of change and uncertainty, self-directed learning is a fundamental competence. However, to date there is a dearth of understanding regarding how digital technologies are supporting or affecting self-directed learning in adulthood. In order to address this, the objective of the present study was to examine through a systematic literature review what is known to date regarding—how can digital technologies support self-directed learning in adult learning and education? The novel findings of the present study suggest digitization has transformed opportunities for self-directed learning in informal, non-formal, and in formal educational settings. However, a key finding of this present study was that the affordances of digital technologies might be described as a double edged sword: (1) digital technologies provide convenient accessibility to information, which acts as an enabler of self-directed learning; but (2) the increasing volume of available information demands additional learner skill in information literacy—part of being a competent self-directed learner—in order to navigate information in a meaningful way. These two concomitant phenomena might in part explain the widening digital divide that has been recorded in recent years.

1. Introduction

Learning skills are fundamental 21st century skills that enable people to thrive in an increasingly uncertain future. Digitization and the current COVID-19 pandemic have been key drivers of uncertain and changing conditions (e.g. [22,129]). In the face of change and uncertainty, learning skills provide persons with the ability to upskill and meet new and unpredictable demands: thus affording persons with resilience to uncertainty and rapidly changing conditions (e.g. [18,26]). Specifically, self-directed learning (SDL) is a learning form that is demanded from adults on a regular basis—if they are to meet the demands of our rapidly changing world, especially in workplace settings. It is well-established that SDL is a fundamental competence for living and working in a world that is characterized by unpredictable and rapid change: SDL can be viewed as a meta-competence that affords a person to learn new knowledge, skills, and competences on a continual and lifelong basis [12].

SDL competence is defined as “the ability to pursue SDL with success and efficiency: to proficiently direct one’s own learning means and

objectives in order to meet definable personal goals” ([9], p. 302). Specifically, SDL competence has been identified as a fundamental competence for adults living in our modern world: SDL competence is especially important for employees to manage rapidly and constantly changing work conditions [1,23,35]; which arguably becomes especially palpable in times of crisis and sudden change that necessitate novel responses—exemplified by the current COVID-19 pandemic. Indeed, since early empirical works on this subject in the seventies (e.g. [131]), scholars have pointed out how fundamentally important SDL competence is for an adult across the course of their life: Tough’s seminal work highlighted how SDL is commonplace employed in everyday life: as a process through which work- or life-centered problems are solved.

SDL is a learning process in which learners take primary responsibility to direct their learning means and objectives in order to meet their learning goals [69]. The process concerns both self-management and self-monitoring of learning tasks [42], which have been referred to as macro- and micro-level aspects of SDL, respectively [58]. From a macro-level perspective, SDL often does not involve learners learning alone in isolation. Actually, empirical studies have

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highlighted how successful SDL often involves working with others, with or without an educator (e.g. [65,120,141]). Moreover, from a micro-level perspective, self-monitoring concerns self-regulatory processes (see [57,94,150] for a review of the self-regulation concept and wider discussion).

Furthermore, scholarly models of SDL commonly emphasize three further dimensions: personality characteristics of persons that are likely to affect their tendency and propensity toward SDL (e.g. [4,67,118]); factors within the person's context that might influence the likelihood of whether SDL is carried out (cf. [87,88]); and, the cognitive aspect of SDL—considering how meaning is made during the SDL process (e.g. [8, 11,42]).

It is important to point out that empirical studies have commonly highlighted that many adult learners are not competent self-directed learners (e.g. [64]). For example, in the context of trialing a vocational education programme in the Netherlands that stipulated young adult vocational learners to undertake self-directed learning, it was concluded that many of the young adult learners did not make sufficient learning progress when tasked with SDL and would benefit from expert support, especially in terms of nurturing the skills necessary for SDL.

On this point, historically scholars within the field of SDL have strongly advocated that formal educational settings represent a salient opportunity to foster learners' SDL competence; it had been summarized that this educational goal has not been realized in most educational contexts worldwide (e.g. [69,72]). Almost two decades ago now, Dunlap and Grabinger [38] argued that as a consequence formal education that does not embrace the process of facilitating SDL is that education is often not adequate for preparing persons who have careers in complex fields or those facing changeable conditions; SDL is a fundamental workplace competence. Workplace competence refers to an employee's ability to act in order to successfully manage their occupational requirements [6, 83].

Indeed, in recent years there has been an increasing need for digital problem solving skills as more workplaces interact and use digital media (cf. [93,138]). Then, arguably, where digitization and the current COVID-19 pandemic have been key drivers of uncertain and changing conditions (cf. [22,129]), SDL can be rather considered as a fundamental workplace competence for a great portion of our working population.

Thus, a key consequence of our information age is a greater emphasis on SDL across all age levels and occupations. New technologies such as mobile devices have transformed the possibilities for teaching and learning (e.g. [45,125]). In this regard, Albedah and Lee [3] have speculated that digitization has transformed learning in informal and non-formal settings, rather than in formal educational settings. However, in contradiction to this, a recent review of childhood learning has outlined how digital technologies are supporting the facilitation of SDL in the formal education of children [14]. But, to date there is a dearth of understanding regarding how digital technologies are supporting or affecting SDL in adulthood, exactly. Therefore, the objective of the present study was to examine through a literature review what is known to date regarding—how can digital technologies support SDL in adult learning and education?

2. Method

2.1. Data collection

Records included in this large-scale review were collected from multiple literature sources in order to collect as many records as possible to address the research question at hand. Specifically, the search term “self-directed learning” was used to search within keywords and/or within title (where practically possible to do so) within all of the following journal data base sources:

- 1 Directly on websites of publishers of academic journals including Springer, Wiley, Sage, and Taylor and Francis;

- 2 Dictionary of Open Access Journals;
- 3 Education Resources Information Center, Web of Science, and SCOPUS journal indexes; and
- 4 Within a journal specific to the topic of SDL that is not indexed in any of the above data base sources: The International Journal of Self-Directed Learning

Beginning with records that were classified as advance online publications, initially records were drawn from the most recently published studies on a year-by-year date basis until saturation of data was achieved ($n = 97$ records; Table 1); which was at the point at which further data did not appear to significantly further the findings and conclusions drawn. This large-scale data collection began in the summer of 2019, when records were collected; the data analysis and interpretation process took many months and was completed in April 2021.

From the systematic search conducted a total of 691 records were initially retrieved. Then a process of document sorting was conducted manually and without automation tools by the lead author of this study who worked independently in this process. During the document sorting process, 322 duplicates were removed and 26 records excluded based on title. Then, from the 296 records left, a further 199 were excluded from consideration in the study after being screened by abstract for eligibility against the inclusion criteria; this included full-text assessment of 233 articles. Inclusion criteria were that the record (1) discussed/implemented digital technologies (2) primarily focused on examining the facilitation of SDL (3) was an empirical study (4) concerned adult learners, and (5) was written in English. No specific methods were used to assess risk of bias in the included studies, and no specific variables were sought. In this respect, assumptions and limitations of the process are outlined in the discussion section of this report. In total 97 records, comprising records classified as Informal Learning ($n = 10$), Non-formal Learning ($n = 11$), and Formal Learning ($n = 76$), were finally included in the data analysis process of the present review (cf. Table 1).

2.2. Data analysis

The data was analyzed using an inductive thematic analysis, in which all research outcomes from the studies included in the review were given full consideration in respect to the research question of the present study. The data analysis process was conducted by three investigators who conducted the data analysis process independently. Investigators sought to analyze, qualitatively, the educational processes outlined in the records—regarding what is known concerning how digital technologies can support SDL in adult learning and education. Prior to beginning the data analysis process investigators were involved in one day of formal training concerning the competent operation of MAXQDA10 for the purpose of the process of data coding. Within the software, the records included in the review (cf. Table 1) were uploaded. Then the process of identifying themes was commenced through a process of inductive coding following six steps of a thematic analysis process ([28], as exemplified by Morris [14]).

An independent analysis was made by each investigator of records, where articles were fully read whilst notes were taken to enable arrival at codes and themes through an inductive analysis. In this respect, the themes and codes were defined during the analysis and were not

Table 1
Summary of journal articles included in the review.

Document classification during systematic analysis	
Informal Learning ($n = 10$): [19,27, 33,34,49,73,74,80,84,142]	Formal learning ($n = 76$): [2,15–17,20, 21,29–31,41,43,46–48,50,52–56,59–63, 70,71,75,77,78,82,86,89,91,92,95, 97–100,102,104–110,112–117,119, 122–124,126–128,130,132–137,139,140, 144–147,151]
Non-formal learning ($n = 11$): [24, 25,36,40,44,66,76,79,81,96,111]	

project where the adult was learning about the topic for the first time (e.g. [79]). Motivation for this learning was commonly driven by curiosity, or enjoyment, a personal growth need, and/or a personal challenge (examples include: learning about menopause, e.g. [34]; learning a foreign language, e.g. [126]; diabetes management, e.g. [107]), or where the learner faces changing social contextual conditions: which leads to knowledge/skill/competence gaps opening up over time.

In this regard, the majority of the studies viewed SDL as a *lifelong* key competence; it is not surprising that the majority of studies concerned workplace related learning in which conditions are constantly changing, such as in medicine (e.g. [27,78,91,97,106,110,114,117]), dentistry (e.g. [16]), teaching (e.g. [19,80,86,142]), nursing (e.g. [116]), pharmacy (e.g. [108]), business (e.g. [76]) etcetera. In this respect, the need, or motivation, for SDL was more often than not experientially driven. Specifically, the process of SDL involved learners taking responsibility for their learning in order to solve or resolve real-world-based questions, issues, cases, problems, or projects. In discussion of Fig. 1, the following sections detail how digital learning technologies supported the self-management and self-monitoring of SDL processes within the studies examined.

3.2. Digital technologies supporting the self-management of self-directed learning

3.2.1. Accessibility to real-world-based experiences brought to educational settings

A key theme in this study (cf. Fig. 1) was that digital technologies enabled real-world-based experiences to be brought into educational settings and this was achieved through a variety of digital resources, including virtual reality as a “powerful” resource. For example, the study from Beach [19], conducted with 15 Canadian elementary school teachers, examined cognitive processes of teachers as they used a professional development website. In this study it was highlighted that teachers valued authentic real world experiences, which were judged as trustworthy and authentic learning resources for their professional development. Teachers highlighted the portability of digital technologies that supported a high level of accessibility to these learning resources for their professional development.

Portability of digital technologies was highlighted in other studies. For example, the study from Yuen et al. [146] discussed the point that access to videos through online and mobile technologies enabled “ubiquitous access” to content and information—access being the key factor in enabling an environment supportive of SDL.

Indeed, from the studies reviewed it was clear that digital technologies afforded learners with access to a virtual learning environment that intently reflected, or sort to reflect or mirror, *as close as possible*, the real-world-based experiences relevant to the topic of learning. For example, Bakker et al. [16] described the implementation of a dentistry trainer within a Dental School in the Netherlands that employed a virtual learning environment where students had control over the pacing of their learning. Moreover, the study from Hardy and Marshall [46], in the context of pharmacy education in the USA, explained how digital technologies were used to facilitate virtual patient cases—emphasizing that the technology affords “opportunity to experience” what happens in practice whilst remaining in a classroom setting. For example, a virtual patient visit was used to simulate how a patient visit would occur from start to finish, which led to an increase in students’ confidence after course completion. Likewise, Lai and Zheng [73] made the argument that language learning experience via mobile devices was a “better” and “real” experience of Japanese learning. Furthermore, in a nursing professional development context with 69 nurses, Roberts et al. [104] discussed how screenshots of an electronic nursing record system were presented via PowerPoint presentations.

In addition, many of the studies reviewed identified that educational programmes adapted an approach to enable access to a variety of media learning resources (e.g. language learning, [145,147]; medical and

dentistry, [128,151]; and nursing, [130]). For example, in a dentistry and medical student educational context at Harvard University, the study from Tain et al. [128] discussed how a multitude of learning resources, such as print, audio, video, were enabled by digital technology and enhanced the team- and problem-based learning experience of students. Moreover, the study from Tohid et al. [130] with 46 nursing students discussed a multi-media approach to learning materials offered to students, such as videos, multimedia quizzes, images, opportunities for authentic interactions, audio material, etcetera. Furthermore, in a study from the USA, Zureick et al. [151] highlighted the point that new instructional digital technologies, such as online lecture video recordings, have increasingly been incorporated into their medical school’s learning environment.

3.2.2. Accessibility to digital resources/platforms

Through digital technologies educators are designing and employing a number of creative and innovative ways to deliver specific learning resources. For instance, the study from Bale et al. [17] that concerned 451 medical (Chiropractic) University students highlighted the point that as part of the learning process and becoming an expert in the field there are naturally occurring anatomical variants that “are not found in the textbook”. The study described the process of development of an Online Catalog, hosted on the Moodle™ learning management system, of Anatomical Variants that are encountered during dissection lab practicals. In the study, the authors noted that more than half of the students indicated that they would actively participate in the continued development of the resource. For instance, case reports were created that included brief videos to document anatomical variants that were discovered. The digital platform enabled interaction and collaboration in the development of and use of this novel digital learning resource. In addition, Horn et al. [52] described the development of and potential challenges of using open educational resources in a competency-based higher education programme. They discussed that the process of finding relevant open educational resources is a time-consuming process because it takes time to evaluate them for relevance and curate them in a meaningful way in order for them to be “useful for learning”.

In discussion of the exponential growth of open educational resources, Kim et al. [66] noted that learners were often not competent on knowing where to start and how to make meaningful learning from the vast amount of open resources available. Moreover, Jimoyiannis and Roussinos [56] highlighted the point that among Web 2.0 applications, wikis have received intense educational interest. The authors discussed that wikis are well known for their affordance to allow students to work in collaboration to create and share content in an active way. In this study, their content analysis showed that the students were successful in engaging in the wiki activities: creating a community of inquiry.

Indeed, many of the technologies supported a collaborative learning environment. For example, the study from Curry [36] documented a non-formal community workspace where technology and people come together to create whatever they want. Curry discussed that the learning environment offers a creative makerspace where learning can happen through success or failure. In another study that promoted SDL as a collaborative process, Hardy and Marshall [46] described the success of an innovative course to prepare students for advanced pharmacy practice experiences. The authors described the implementation of a multitude of collaborative learning experiences enabled through digital technologies including Blackboard Collaborate™ which was used as the medium for online chat discussions about articles. Moodle™ was used as a means of communication with students and to facilitate interactions with the virtual hospital system that was set up for the purpose of learning.

Furthermore in this regard, Golightly [43] examined the fostering of South African trainee geography teachers’ SDL readiness with collaborative online and face-to-face problem-based learning, longitudinally over a 3 year period. Golightly explained that in online problem-based learning a key benefit was that learners were able to work online

whenever it suited them. Students were demanded to do research in their own time and explore various kinds of information such as library resources, text books, maps, and field studies. This study outlined that problem-based learning is anchored in ill-structured, real-world-based problem solving that focuses on students investigating problems rather than being directly instructed by educators. The author concluded that the trainee teachers' SDL readiness scores increased over a three year period. It was apparent that students were challenged in the fact that they reported that tutors were not necessarily immediately available to support their online problem-based learning pursuits and they therefore had to work things out for themselves.

Also, highlighting the collaborative nature of SDL, Herod and Kop [49] explored 19 adults' informal learning activities regarding their use of an "Out of the Storm" online self-help forum, which presents as an opportunity for two-way collaboration and informal SDL. All participants said that they began using the platform because it was free and accessible. The authors discussed that the forum enabled persons to connect with each other and create and exchange information and digital resources.

Furthermore, the study from Canty et al. [31] examined the effectiveness of a novel technology for teaching cardiac ultrasound to 145 Australian physicians. In this study, SDL with a simulator course was trialed, compared to traditional instructor led training. The authors highlighted the positive cost effectiveness of the self-directed course, achievable because the instructor time was heavily reduced to three hours per five participants—a four-fold reduction in instructor time—meaning that it was cheaper to run and therefore was deemed a scalable solution for training, especially in a field where there is a lack of availability of trainers.

Similarly, Friedman et al. [41] examined the effectiveness of a novel interactive simulator that provided diagnostic simulations of 84 cases selected to maximize exposure to important diagnoses in musculo-skeletal radiology with 43 American medical students. Indeed, in comparison to the traditional observational teaching methods the authors reported improved competence scores with use of the interactive simulator—a simulator that the authors described as a learning process that enabled SDL; as it was common for students to proactively search for additional information via the internet to complement the learning process through the simulator.

It was clear that digital technologies enabled *choice* in many studies examined. Interestingly in the study from Ibrahim et al. [54] that examined the reading habits of 225 Canadian medical students it was noted that students reported preference for print materials, however most resources students used were digital materials. Students noted cost and convenience reasons for use of more digital resources. In a different context, Beach [19] described web-based learning environments as primary sources of information for teachers that come in a variety of forms. Likewise, Supriyono [126] described that learners in the context of language learning in Indonesia were subjected to practice of "material exploration", where learners independently search for relevant learning materials, such as e-books, journal articles etcetera via the internet.

Moreover, the study from Cooper [34], which involved 227 American women aged 35–55 years, focussed on understanding SDL efforts of women during their pursuit to learn about menopause. Many women had proactively learned about menopause, from a variety of sources including medical and non-medical websites, friends, family, books, magazines, and women's centers, etcetera. Women in this study voiced that the Internet was considered as more convenient than books; but websites had to be considered reliable and accurate as primary reasons for using particular websites. However, almost two-thirds of the women indicated they had difficulty with their search—stating that the information they needed was not available; thus highlighting the point that it cannot be assumed that adults have fostered the necessary competence to undertake a SDL project, without the presence of an educator. Moreover, most women stated that they were not concerned about the accuracy of information found, some noted that they found difficulty in

determining which information was credible and which was not.

In addition, it seems necessary to consider that technologies might enable the appropriate scaffolding for learners—an example of which is discussed in the study from Beckers and colleagues [20]. In a parallel study the authors highlighted the point that often learners benefit from, or even demand, support from an educator; but different students demand differential amounts of support [21].

Indeed, in learning situations where no or little learner support is readily available, progressions in SDL for many learners is slow and/or can lead to learners dropping out of educational programmes. This is exemplified in the study by Botero et al. [25] who documented that applications such as Duolingo can encourage out-of-class learning, but their interviews with students revealed a lack of sustained motivation and low usage of the application. Similarly, in studies examining student engagement in Massive Open Online Courses, it is discussed that it is well documented that there is a growing amount of students signing up to start such open educational resources, however the retention rate on such programmes is generally very low, but higher in individuals who have already completed a higher educational qualification [24,79].

Indeed, the lack of readiness for SDL was documented in many of the studies reviewed. For example, Tain et al. [128] reported that first year dental and medical students at Harvard University demonstrated a lack of readiness for SDL, where specifically students generally lacked the competence to choose the "most useful" resources for learning. The authors' perspective in this regard was that an important role of an educator is therefore to provide such appropriate resources. We contest this statement later on in our discussion—where we highlight the point that it should be considered that post-formal education learners are often left without a teacher and therefore fostering SDL competence through the formal educational process seems a logical and salient goal. On this point, Zainuddin and Perera ([147], p. 281) argued that the "implementation of teacher-centered approaches in today's digital age is becoming irrelevant due to the many freely available content provided on the internet which enable students to access them at any time". As we later discuss, the caveat of this statement is that there is an underlying assumption that adults are competent self-directed learners.

3.2.3. Accessibility to multiple sources of feedback

Digital technologies enabled access to multiple and/or non-traditional sources of feedback, which was often timely and sometimes automatic and/or instant. Some technologies facilitated instantaneous or automatic feedback about learner's progress. For instance, the study from Bakker et al. [16] exemplified a dental trainer that incorporated an automatic assessment system that provided instant feedback to learners. The authors explained that a key advantage of the system was that it enabled self-paced learning that incorporated good-quality external feedback to facilitate progress, without being dependent on the availability of a teacher. Moreover, the study from Sando and Feng [108] described the use of an online "spaced-education" game to study drug information with 236 first year Pharmacy students in the USA, where the technology enabled students to receive immediate feedback on their answers submitted.

Many studies described the affordability of digital technologies to support self-assessment. For example, the study from Beckers, Dolmans, and van Merriënboer [21] comprised 22 young adult vocational education students in the Netherlands and examined the implementation of an Electronic Development Portfolio. The authors explained how the portfolio helped students to engage in weekly self-assessment of their progress in order for the learners to identify points for improvement. Beckers and colleagues noted that this integrated self-assessment process relieved teacher workload, where there was integration of students' self-assessment and teacher-assessment scores. The authors did however note that students had difficulty in selecting the appropriate criteria for self-assessment, which limited the perceived success of the students in formulating appropriate points for improvement.

In comparison, the study from Jimoyiannis and Roussinos [56],

conducted in the context of Greece with 47 Higher Education students within the Department of Social and Educational Policy, examined the creation of a wiki-project as part of a blended learning course. They explained that the wiki enabled informal discussion, exchange of information and ideas, and encouraged peer-feedback about changes, improvements, and revisions to the wiki pages created by the students.

Moreover, Khodary [63] examined use of Emodo with 45 Language and Translation University students in Saudi Arabia. The author explained how learners evaluated their own learning performance on Emodo through writing a reflective piece. Additionally, whole class discussion was used in order to stimulate group reflection on the learning process.

Indeed, in many of the studies examined, the reviewing phase of learning involved interaction and collaboration between learner and teacher but also between learner and other learners, representing a community of practice. In particular, some studies explained how digital technologies were used to facilitate peer-review. For instance, the study from Herzog and Katzlinger [50] involved 765 Digital Business students from two different Universities in Germany and Austria where electronic peer-review was implemented within the learning management system Moodle™. The authors described the peer-review process as “additional feedback”. In this study, students asked that the peer-review criteria should be discussed before starting the work and that each work should receive feedback from at least three peer-reviewers in order to mitigate the lack of knowledge of some of the reviewers. Similarly, in a study with 76 Biological Science University students in the UK, Slee and Jacobs [119] required students to upload a peer-review, which was worth 10% of the overall assessment mark.

3.3. Digital technology platforms to assist monitoring of self-directed learning

Some studies documented novel digital resources or platforms that had been incorporated into their educational programmes in order to assist monitoring of progress of learning goals. For example, the study from Jouault et al. [59], which involved 24 Japanese University students studying history, discussed a digital technology platform that automatically generated questions to support learners in identifying their learning goals: to prompt students’ self-regulation in an open learning space. Moreover, a study by Onah and Sinclair [92] with 107 students who were registered participants on a Massive Open Online Course studying computer science described a novel context management system in which students choose their learning route in order to obtain their own learning objectives or could alternatively choose to follow the pathway chosen by the instructor.

Other studies highlighted that students are expected to go beyond the learning resources offered to them by the instructor; for example, Sawarynski et al. [109] discussed the need for medical students to incorporate self-directed benchmarks into their plans. Some discussed tools to support students in setting and managing their own learning goals, such as ePortfolios to support the continuing professional development of rehabilitation professionals [40].

Furthermore, Lejeune et al. [76] examined longitudinal data on 3661 employees working in 16 countries who are using a talent management system—in which companies seek to create a supportive environment to support the continued development of talented employees. Lejeune and colleagues explained that companies are investing heavily in talent management strategies, including in electronic human resource systems that support talent management.

Indeed, more often than not, in order for learners to progress successfully with technology assisted planning and monitoring tools, support from others—often an expert—was necessary for effective implementation. In this regard, the study from Schmidt-Jones [111] highlighted the point that the ability of the learners to choose suitable inquiry resources is crucial to learning progression. Moreover, Jouault et al. [59] discussed that it is often difficult for learners to plan their

learning effectively when they are unfamiliar with the learning domain. Specifically, in order for a person to plan an effective learning project the learner would need to create good inquiry questions, but the authors argued that an understanding of the domain is a prerequisite for developing good inquiry questions—thus some learners would benefit from support in this regard. In fact, in the studies reviewed, SDL was commonly viewed as a process that was guided by an expert in the field (e.g. [102,105]).

4. Discussion

4.1. Motivations for self-directed learning

It is interesting to first identify that motivations for SDL were mostly driven by the need for an increase in knowledge, skill, or/and competence—a knowledge/skill/competence gap. It is well-established that, in a world that is characterized by unpredictability and rapid change, SDL is a fundamental competence (e.g. [8,10,72]). The present study concurred with these theoretical assumptions. In this regard, a majority of the studies viewed SDL as a *lifelong* key competence for remaining up-to-date with knowledge, skills, and competence.

4.2. Digital technologies supporting the self-management of self-directed learning

4.2.1. Accessibility to real-world-based experiences brought to educational settings

A key theme in this study was that digital technologies enabled real-world-based experiences to be brought into educational settings (e.g. [16,46]). Often real-world-based resources were judged as trustworthy and authentic learning resources for the purpose of professional development (e.g. [19]; cf. [37] for discussion on authenticity and engagement; also [13] for discussion on SDL and contextual quality of experience). Virtual reality is a good example of technology that provides a real-world-based sense of immersion and presence (cf. [90]). There is surmounting evidence that digitization has caused a dramatic change in the nature of education. Indeed, Soe et al. [121] even describe the growth of prevalence of use of online videos in Higher Education as “pervasive”, highlighting the point that it is important to consider both the positive and negative effects of digitization upon teaching, learning, and education.

In addition, many of the studies reviewed identified that educational programmes adapted an approach to enable access to multiple forms of immersive digital media learning resources (e.g. [145,147]). In this respect, *accessibility* was the key affordance of digital technologies which supported the facilitation of SDL.

In sum, the convenience and accessibility afforded through digital technologies are proving very useful for adult learners—especially in regard to professionals who work in careers where there is a constant demand to adapt to changing work conditions. As adaptability has been proposed as being absolutely necessary for professional expertise [143], it can be said that digital technologies are proving to be a valuable tool to support the development and maintenance of professional expertise.

Although literature on SDL has claimed that digitization has transformed learning in informal and non-formal settings, rather than in formal educational settings (e.g. [3,24]), the present study did not necessarily concur with these speculations. Rather, it was clear that new digital technologies are affecting the nature of teaching and learning in formal educational settings alongside informal and non-formal settings. Importantly, the studies examined in this present study provide evidence that in a variety of educational contexts worldwide educators are answering the calls of scholars—that formal educational settings represent a salient opportunity to foster learners’ SDL competence (cf. [38, 72]).

In this regard, the summary from Dunlap and Grabinger in 2003 that formal education does not embrace the process of facilitating SDL,

thankfully, two decades later, can be partly debunked by this present study. Actually, some studies detailed formal education programmes that target the fostering of SDL competence over time (e.g. [43]), which addressed the call in the field that SDL competence is not likely fostered in a short period of time, but rather over months or years requiring patience and time on part of the educator (cf. [14]).

4.2.2. Accessibility to digital resources/platforms

In the studies reviewed in the present study, it was clear that through digital technologies educators are designing and employing a number of creative and innovative ways to deliver specific learning resources (e.g. [17,52]). This included the important phenomenon that there has been and continues to be an exponential growth of open educational resources [66], including the use of and availability of wikis (cf. [56]). Accessibility was the central affordance of new digital technologies, which supports discussion of previous studies on the affordances of mobile devices such as tablets [45]. Moreover, studies reported upon an array of innovative and creative digital resources and platforms that often support a collaborative learning environment. Indeed, competent SDL inevitably involves a collaborative process (cf. [42]). Alongside accessibility and convenience, programmes that implemented novel digital technologies were often considered effective for learning and affordable—meaning that digital technologies more often than not made a higher level learning experience more cost-effective—especially in situations where educators are a scarce, valuable, and expensive resource (e.g. [31]).

Although digital technologies enable accessible and convenient learning resources, an important finding of the present study was that studies described that some adult learners do not hold the necessary inquiry skills to successfully undertake SDL. Information literacy skills were highlighted in studies as being fundamental skills of inquiry that includes the skill of finding and utilizing the “most useful” learning resources and then thinking critically and making balanced judgements about information within the learning resources in respect of meeting their SDL goals and objectives. For example, in the study from Tain et al. [128], which involved Harvard University first-year dental and medical students, it was concluded that students were not using the most effective learning resources despite them being freely available. On the point of availability and usage of educational resources, Kim et al. [66] noted the point that just because there is a growing number of openly available resources does not mean that adults can make meaning of them: many adults find it challenging to successfully use the available learning resources to meet their learning needs. The study from Cooper [34] exemplified this issue: he reported that almost two-thirds of the American women in his study ($n = 227$; 35–55 years old) had difficulty with searching the internet—stating that the information they needed was not available. Moreover, most women stated that they were not concerned about the accuracy of information found, some noted that they found difficulty in determining which information was credible and which was not. In this respect, Cooper [34] highlighted the point that it cannot be assumed that adults have fostered the necessary competence to undertake a SDL project, without the presence of an educator. In this regard, it could be summarized that many adult learners were *adrift in a sea of information* afforded through digital technologies and access to the internet: lacking information literacy (cf. [101] for further discussion).

A key direction for further studies on SDL therefore concerns the potential dangers of undertaking SDL when learners do not hold sufficient information literacy skills. It was not the intention of the present research to review educational processes that have proven successful in fostering the skills of information literacy (note however that there is much research interest presently on this important issue e.g. [32,103]), but further studies are required to confirm a key conclusion from this present report: that information literacy skills are prerequisite for competent SDL in our information age. On this point, most recently Hong et al. [51] have highlighted the importance for learners to adopt a critical attitude when engaging in the inquiry learning process. As well

as representing a key direction for further research, this supports the notion that many adult learners need support over time to foster the necessary skills and attitudes to enable competent SDL.

Indeed, the study from Beckers, Dolmans, Knapen, and van Merriënboer [21] recommended that students should receive enough timely feedback and support during the acquisition of SDL skills over time. Although there is a distinct lack of longitudinal studies in this regard—and longitudinal studies examining fostering of the inquiry skills necessary for competent SDL over time are a necessary direction for further studies—the study from Golightly [43] demonstrates how the necessary inquiry skills, or “SDL readiness”, can be improved over a three year problem-based learning programme.

It should be noted here that it is well known that when facilitating SDL in formal educational settings different students demand differential support (cf. [21]). Indeed, in learning situations where no or little learner support is readily available, progressions in SDL for many learners is often slow and/or can lead to learners dropping out of educational programmes [25]. This is perhaps most clearly evidenced in Massive Open Online Courses, where it is well documented that there is a growing amount of students signing up to start programmes, however the retention rate on such programmes is generally very low, but higher in individuals who have already completed a higher educational qualification [7,24,79,148]. In this respect, it should be considered that successful SDL in a digitized world likely necessitates SDL competence [65], but also other 21st Century skills and competences, such as digital competence and information literacy (cf. [85,149]).

4.2.3. Accessibility to multiple sources of feedback

Another benefit of digital technology was that it enabled access to multiple and/or non-traditional sources of feedback, which was often timely and sometimes automatic and/or instant (e.g. [16,108]). Many studies described the possibilities of digital technologies to support self-assessment (e.g. [21]) and peer-assessment [56]; potentially reducing teacher workload, but also then facilitating the fostering of the reviewing aspect of SDL competence—which does not traditionally form part of a teacher-directed educational programme (cf. [69]).

4.3. Digital technologies supporting the self-monitoring of self-directed learning

Finally, as well as assisting the self-management of SDL, some studies documented novel digital resources or platforms that had been incorporated into their educational programmes in order to assist monitoring of progress of learning goals, whether through computer assisted ongoing development of learning objectives (e.g. [59]), context management systems in which students choose their learning route (e.g. [92]), learning plans with SDL benchmarks [109], or computer assisted talent management systems for management of professional development (e.g. [76]). Again, a commonality of which was that learners were offered support by a relevant subject expert in their learning process.

4.4. Limitations of this study

There are limitations that should be considered in interpreting the findings of this present study. Perhaps most importantly, in the process of data synthesis there were underlying epistemological investigator assumptions that SDL is a process that is important for adult learners. However, readers of this report should consider that SDL (including through digital means) might not be possible and/or desirable in some contexts (cf. [39]). Also, it should be considered that previous studies have highlighted the mediating effect of personality characteristics, which are likely to affect an individual’s tendency and propensity toward SDL (e.g. [4,118]) and it was not possible to examine such effect in the present study.

Furthermore, there were limitations of the methodology conducted. The focus of the analysis was not quantitative analysis and thus methods

were not used to assess risk of bias, robustness, certainty or confidence of the findings in the present study. However, at the same time, given the limitations highlighted above regarding the effect of contextual factors and personality characteristics, as well as the very differential nature of the process of SDL in terms of learning means and objectives as detailed in the present study, it is probable that conducting fruitful quantitative analysis at a review level might be difficult on this topic.

Moreover, we highlight in the introduction section of this report that digitization and the current COVID-19 pandemic have been key drivers of uncertain and changing conditions (e.g. [22,129]). In this respect, a key strength of the present study was its relatively large-scale nature; but, at the same time this research process took time from data collection through data analysis and publication of findings. Thus, it is quite possible and likely that due to the rapid speed of changing conditions repeating the study at any time point would lead to further novel findings. On this point, it should be considered that findings of this review presents knowledge on this topic within a snap shot of time—and therefore this review could present as an important reference point for comparison for further studies.

5. Conclusion

SDL is a key *lifelong* meta-competence for remaining up-to-date with knowledge, skills, and competences. Digital technologies are transforming educational opportunities for SDL and in regard of the findings of this report we conclude with seven key guidelines for further research, practice and policy in respect of our understanding of successful facilitation of SDL in educational settings in our digital age:

- 1 SDL should be an important component of educational programmes, especially for programmes that are designed to prepare learners to work in job fields in which conditions are constantly changing.
- 2 In engaging learners in educational processes seeking to practice or promote SDL, the educational processes should spark learner motivation by targeting a knowledge/skill/competence gap and/or be clearly linked to the learner's interest(s).
- 3 Educational activities that facilitate SDL should task learners to take responsibility for their learning in order to solve or resolve real-world-based questions, issues, cases, problems, or projects.
- 4 Educators should highlight to learners the importance of considering the details of context in the SDL process; there should be consideration of how digital technologies can be used to provide learners a "rich contextual experience"—to reflect or mirror, *as close as possible*, the real-world-based experiences relevant to the topic of learning.
- 5 It should be considered that SDL in formal educational settings, somewhat paradoxically, is inevitably a collaborative process with interaction, feedback, and support. This is the case for all phases of the management and monitoring of SDL and there are novel digital technologies that can be implemented to support these dimensions of the SDL process and to foster a "community of inquiry". It should be considered how collaboration, interaction, support, feedback, and monitoring of learning processes can be enhanced with digital technologies, but also that a skilled and knowledgeable educator themselves can contribute significant value in terms of progression in these learning processes.
- 6 There must be an intention and priority of any SDL educational programme to improve learners' inquiry skills necessary for SDL over time, with acknowledgement that every learner will have a differential SDL readiness. The educator should seek to, at the very minimum, foster basic skills of inquiry: information literacy being a key inquiry skill that includes learner skill of finding and utilizing the "most useful" learning resources and then thinking critically and making balanced judgements about information within the learning resources in respect of meeting their SDL goals and objectives.

7 A skilled and knowledgeable educator will be invaluable for designing educational programmes to successfully implement guidelines number 1–6.

It can be summarized that affordances of digital technologies might be described as a double edged sword: (1) digital technologies provide convenient accessibility to information, which acts as an enabler of self-directed learning; but (2) the increasing volume of available information demands additional learner skill in information literacy—part of being a competent self-directed learner—in order to navigate information in a meaningful way. Thus, in our information age skill in information literacy is pre-requisite for competent SDL. The challenge for most learners may come therefore when they leave formal educational settings and suddenly face the need to undertake SDL, without the support of an educator. This present research paper points out that competent SDL is not easy and takes considerable skill that for many learners needs to be fostered over time, perhaps many years.

These two concomitant phenomena central to this present research might in part explain the widening digital divide that has been recorded in recent years: where competent self-directed learners are able to make full use of convenient accessible information afforded through digital technologies, but at the same time the increasingly availability and different forms of information actually demands more learner skill in order to competently undertake SDL leading to a portion of the adult population that might remain "lost at sea" through their life course when facing vast quantities of information on the internet—a deep disadvantage, especially when facing times of rapidly changing conditions where adapting to change through SDL is fundamental to working and living. Digitization and the current COVID-19 pandemic have been key drivers of uncertainty and changing conditions. Perhaps, then, the COVID-19 pandemic together with digitization will be the tipping point in which facilitating SDL in educational settings becomes a normality: part of fundamental educational change where emphasis is placed on fostering 21st century skills that enable people to thrive in, and meet the demands of, our rapidly changing world and an increasingly uncertain future.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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