Investigating the Well-being Impacts of Educational Technologies Supported by Learning Analytics:

An application of the initial phase of IEEE P7010 recommended practice to a set of cases

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The accelerated adoption of digital technologies by people and communities results in a close relation between, on one hand, the state of individual and societal well-being and, on the other hand, the state of the digital technologies that underpin our life experiences. The ethical concerns and questions about the impact of such technologies on human well-being become more crucial when data analytics and intelligent competences are integrated. To investigate how learning technologies could impact human well-being considering the promising and concerning roles of learning analytics, we apply the initial phase of the recently produced IEEE P7010 Well-being Impact Assessment, a methodology and a set of metrics, to allow the digital well-being of a set of educational technologies to be more comprehensively tackled and evaluated. We posit that the use of IEEE P7010 well-being metrics could help identify where educational technologies supported by learning analytics would increase or decrease well-being, providing new routes to future technological innovation in Learning Analytics research.

CCS CONCEPTS • Human-centred computing

Additional Keywords and Phrases: Digital well-being, Learning analytics, Ethics, Values

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1 INTRODUCTION

As a result of the rapid deployment of Information and Communication Technologies (ICT) and their uptake by society, individual and social well-being is now intimately connected with the state of our information environment and the digital technologies that mediate our interaction with it [1]. This poses pressing ethical questions concerning the impact of digital technologies on our well-being that need to be addressed. Moreover, the increasing use of data analytics and Artificial Intelligence (AI) methods in the design and use of digital technologies makes such ethical questions more urgent, and emphasise the need of these technologies to be guided by societal and ethical design principles to prioritize human well-being [2].

While AI algorithms are becoming more effective in public and private life, the field of Education has been influenced by this drastic shift in both quantity and quality of data generated from the use of ICT, allowing various forms of analytics to be conducted on educational data for the purpose of tracking learning progress [3]. The scientific community of Learning Analytics (LA) is increasingly concerned about ethics. A broad variety of practical and policy work has arisen to foster ethical practices in the collection and use of educational data, addressing data privacy issues [4, 5, 6], and extending to societal values such as transparency, trust, fairness, accountability and social well-being [7,8, 9, 10]. However, there is a gap in research concerning how we can holistically assess the impact of data-driven educational technologies on the well-being of students and teachers.

The global efforts toward evaluating the impacts of the use of algorithms and analytics on humans' well-being continue to establish societal guidelines for such systems to remain human-centric, serving humanity's values and ethical principles. One of the latest endeavours in this direction is the production of the IEEE P7010 Recommended Practice for Assessing the Impact of Autonomous and Intelligent Systems on Human Well-being, a recently approved standard aims at establishing well-being metrics to "enable programmers, technologists and engineers to better consider how the products and services they create can enhance human well-being based on a wider spectrum of measures than growth and productivity alone" [11].

To this end, this paper proposes to apply the first activity of IEEE P7010 Well-being Impacts Assessment WIA, a methodology to iteratively assess digital well-being, to the creators of ten educational technologies, and present their selections of indicators that reflect potential impacts of these technologies on multiple domains of well-being. We posit that the use of IEEE P7010 recommended practice could help identify where educational technologies supported by LA would increase or decrease well-being, providing new routes to technological innovation in LA research.

The structure of this paper is as follows. We first briefly review the ongoing discussions on LA ethics and values; the concept of digital well-being and its implications in educational contexts; and the theory of Value-sensitive Design (VSD). Second, we explain the general use of IEEEP7010 recommended practice, with a focus on the first activity of WIA methodology, internal analysis. Third, we explain the methods used in conducting this study. Then we highlight the findings and conclude the paper by discussing the promises and challenges of evaluating LA well-being impacts.

2 STUDY CONTEXT

2.1 . Ethics and Values of Learning Analytics

The concern for values embedded in technology design can be linked back to a lengthy and complex context, and the same is true for the narrower debate on technology and ethics [11]. Just as data analytics and Artificial Intelligence AI have brought digital technologies to a new level of ability and influence, they have posed ethical concerns that are more crucial than ever before. Education, like many other sectors, has been affected by the growing use of ICT applications among people and societies, and thus by the so-called data revolution and the era of AI. The integration of ICT in the conduct of educational processes produce important amounts of educational data, which have become available for advanced modelling and analysis to track, understand, personalize, and predict students' performance. Big and small data techniques are being presented and used in Education in the form of Learning Analytics, raising thorny ethical questions about how and what data are dealt with.

Learning Analytics are the processes of collection, measurement, analysis and reporting of learners' data for the purpose of understanding and optimizing learning and the environment in which it occurs [13]. Educational data-driven tools and services are built through the blend of data analytics tools (e.g., dashboards, recommender systems, machine learning algorithms, etc.) into various types of educational technologies and academic technology infrastructure (e.g. Learning Management Systems LMS). The concerns of LA applications are driven not only by finding ways to enhance learning, but also by evaluating LA processes themselves and their wider positive and/or negative impacts on individuals and societies. Many outstanding concerns in LA revolve around data, where the issue of privacy and de-identification of data has been in the heart of these concerns alongside other issues of the location and interpretation of data; and the classification and management of data [14]. In order to solve data-centric ethical problems, LA researchers [6, 8,15] have made use of existing policy frameworks for data privacy and protection by reducing their complexities into principles to guide the design cycle of LA systems. Several other policies and ethical frameworks for education have tried to tackle data-centred ethical consideration in the adoption of LA, including the privacy issue and extending to the societal values of transparency, trust, fairness, and accountability [9, 10, 12].

2.1.1 Value-Sensitive Design VSD

A common theory to ethically sound technology design is Value-sensitive Design VSD, "a theoretically grounded approach to the design of technology that accounts for human values in a principled and comprehensive manner throughout the design process.'' [16]. As a methodology, VSD involves three types of investigations: conceptual, empirical, and technical [28]. Although it has been found difficult to justify the implicit premise that carefully designed technology intentions would correspond to the end use of technology [11], the new abilities of data analytics and AI techniques to track and predict how a certain technology is used have significantly bridged this gap between the design context and the use context. However, these automated measurement processes could themselves lead to lower levels of well-being [1]. An empirical evidence of this approach in LA research included a recent study where two cases of applying the Value Sensitive Design to LA scenarios demonstrated that this approach could balance a wide range of human values in the design and development of LA [8]. Through a conceptual investigation of an existing LA tool, it has been found that the following values can be in tension with other values: autonomy, utility, ease of information seeking, student success, accountability, engagement,

usability, privacy, social well-being (in the sense of belonging and social inclusion), cognitive overload, pedagogical decisions, freedom from bias, fairness, self-image, and sense of community [8].

2.2 Digital Well-being

As a result of the rapid deployment of digital technologies and their uptake by society, individual and social well-being is now intimately connected with the state of our information environment and the digital technologies that mediate our interaction with it, which poses pressing ethical questions concerning the impact of digital technologies on our well-being that need to be addressed [1]. The expression “digital well-being” is used to refer to the impact of digital technologies on what it means to live a life that is good [17]. The conception of well-being, however, should not be perceived as one-dimensional value. Well-being refers to what is directly or ultimately good for a person or population, and encompasses the full spectrum of personal, social, and environmental factors that enhance human life and on which human life depend [2].

A recently published thematic review of the literature on the ethics of digital well-being identify major issues related to four social key domains where digital technologies have increasing roles and impacts: health and healthcare; education and employment; governance and social development; and media and entertainment [1]. The authors refer to a number of articles that discuss how a variety of digital technologies could support lifelong learning, self-fulfilment and openness to new opportunities [18], how gamification-based learning could improve students’ cognitive skills [19]; and how smartphones could automatically detect a student’s mood and help with work-life balance and management through increased awareness of stress and emotional understanding [20]. The review indicates other several human-computer interaction studies centred on the relation between stress and individual well-being and suggest means of automated measurement to deduce users' psychological state [20, 21 22, 23]. Far fewer papers, according to the review, concern how the process of automated measurement could itself lead to lower levels of well-being. One of these papers is a recent study that discovers how the use of digital technologies in schools for the purpose of employee measurement or performance management can have a negative impact on teachers’ morale and sense of professional identity [25]. This thematic review ends with an argument stating that the three broader themes of *positive computing*, *personalized human–computer interaction*, and *autonomy and self-determination* will be central to ongoing discussions and research by showing how they can be used to identify open questions related to the ethics of digital well-being [1]. Positive computing adopts an interdisciplinary perspective to study the individual and social factors that foster human flourishing in order to understand how to design digital interfaces that promote users’ well-being by embedding ethics more closely within the design process [25, 26]. Questions that remain unanswered includes whether positive computing methods, personalized monitoring of employee; or automated measurement processes should be used to improve student and teacher well-being? [1].

2.3 IEEE P7010 Recommended Practice for Well-being Impacts Assessment WIA

The IEEE Global Initiative on Ethics of Autonomous and Intelligent Systems A/IS is a body of work with standards projects, certification programs, and global consensus building to ensure everyone involved in the research, design, manufacture, or messaging around intelligent and autonomous systems is educated, trained, and empowered to prioritize ethical considerations so that these technologies are advanced for the benefit of humanity.” [2]. The initiative aims at providing insights and recommendations to 1) advance discussions about how we can align A/IS to defined values and ethical principles that prioritize human well-being, and 2) provide

recommendations for IEEE Standards based on Ethically Aligned Design, a vision of guiding the design, development and implementation of data-driven technologies by the following general principles: human rights, well-being, accountability, transparency, awareness of misuse [2].

The latest effort of the initiative regarding the principle of well-being is the IEEE P7010 Recommended Practice for Assessing the Impact of A/IS on Human Well-being, a recently approved standard aims at establishing well-being metrics to "enable programmers, technologists and engineers to better consider how the products and services they create can enhance human well-being based on a wider spectrum of measures than growth and productivity alone" [27]. IEEE P7010 standard provides specific and contextual well-being metrics within a systematic approach for a multi-disciplinary understanding of how A/IS may impact human well-being. This approach aims at providing technologists with impact-related insights that should be taken into account throughout the lifecycle of any A/IS to help safeguard individual and societal well-being [27].

As a methodology, IEEE P7010 Well-being Impact Assessment (WIA) is "an iterative process that entails producing a well-being indicators dashboard and using it in the design, development, deployment and continual improvement of an A/IS in order to help safeguard and improve human well-being" [27]. This process consists of five activities: 1) Internal, user, and stakeholder analysis, 2) Well-being indicators dashboard creation, 3) Data collection plan and data collection, 4) Well-being data analysis and use of well-being indicators data, and 5) Iteration. The recommended practice provides a wide range of indicators drawn from well-being measurement instruments already in use and have been proven to be an accurately measurement instrument (i.e. scientifically valid) to be used to primarily assess the impacts of technology on the following domains of well-being: satisfaction with life, affect (feelings) , psychological well-being, community, culture, education, economy, environment, government, health (physical and mental), human settlement, and work [27].

The application of WIA approach to a given tool implicates the three levels of investigation in VSD methods. In the conceptual level, the tool's objectives and users are identified, well-being domains where the system have potential impact are analysed, and indicators to reflect this impact are selected by the tool's creators. In the empirical level, users and other stakeholders of the tool are engaged to reflect on the selected and non-selected well-being indicators for better understanding on how the tool can impact their well-being. Technical investigations are then carried out either to automate the process of gathering well-being data, or to modify the tool based on well-being data; or both. Since the process of data collection and management for the use of this recommended practice can itself have negative impacts on well-being, other codes and guidelines (e.g. data protection regulations, such as GDPR in Europe) have to be followed in conjunction with the application of this standard to address ethical considerations related to data agency.

3 METHODS

This study was conducted by applying the first task of the first activity of the IEEE p7010 standard, initial internal analysis, to the creators of ten educational tools and services that were in different stages of design lifecycle. The cases were selected to be including both data-driven educational technologies and other technologies that hold the potential for future automated data analytics processes. The task was conducted with the aim of increasing the participants' awareness of well-being domains and indicators, and therefore their capacity to address and evaluate the well-being impacts of their systems. This activity was applied to answer the following questions about each tool involved in the study:

- What is the educational tool / service?

- What is the need it meets/ goal it seeks/ problem it solves?
- Who are the intended and unintended users and stakeholders?
- What are the possible impacts on human well-being? And what is the probability of their occurrence?

By answering the four questions above, the participants were expected to have both understanding and grasp on limits of understanding of how their systems may have positive and/or negative impacts on intended and unintended users and stakeholders.

3.1 Participants and Limitations

This initial internal analysis was designed to be conducted by the creators alone and should involve forecasting, hypothesizing, projecting, utilizing scenarios and other means of internal analysis. Based on that, this study was limited to 12 researchers and practitioners in the field of learning technologies who were involved in the creation and management processes of ten different technological tools with various educational objectives. Three of the participants were post-doc researchers, four were pre-doc researchers, four were master students and one was a scientific software engineer. The tools they had been working on included five learning design communities supported by lesson planning tools, and one from each of the following: computer-supported collaborative learning scripts, multimodal LA to support collaborative face-to-face learning environments, a tutoring system to support teenager against dangers they may confront in online social platforms, a classroom orchestration tool to support students' self-regulation, and a learning community platform that follows a citizen science approach (Table 1). Each participant analysed one tool. Even though some of them analysed the same tool, they did so separately and independently.

It is particularly important to state that the outcome of this analysis is only a first step toward a holistic understanding of the potential well-being impacts of each tool involved in this study. The intended and unintended users and stakeholders identified by the creators in this task must be engaged to provide further understanding on the impacts these tools may have on them. The assumptions arriving from this task should be tested through users' engagement and the well-being indicators should be revised based on their reflections before moving to technical investigations.

3.2 Internal analysis process

The participants were engaged in this internal analysis activity to answer the study questions through three rounds of online-based workshops to present the content, followed by asynchronous individual analysis and post-activity interviews. The WIA methodology provides 134 indicators that measure 12 well-being domains (2-23 indicators per domain). The workshops were conducted in a manner allowed each participant within 2-3 hours to: 1) write the system's goals, users, and stakeholders in one's own words to include all possibilities of unintended stakeholders, 2) read the definitions and indicators of each well-being domain, 3) select indicators reflecting impact of the system, 4) allocate the selected indicators into a table of 12 rows (well-being domains) and three columns (users, stakeholders, and the society). This resulted in several indicators distributed to reflect possible impacts of each system on specific domains and specific groups of population; and therefore, initially identify where these systems could impact well-being. The participants were guided by a Yes/No checklist to ease the analysis process and help them answer the questions of IEEE7010 initial phase, and to ensure that every step is completed before moving to the next one. The workshops were followed by one-to-one and small

groups interviews, where the participants were asked to provide justifications and feedback on why they selected each indicator and briefly reflect on the process. Those who worked separately on similar cases were interviewed later together in small-group discussions, while the others were interviewed individually.

4 FINDINGS

Among 134 indicators that had been presented to the participants, they selected a total of 54 indicators to reflect the impacts of their tools on the different domains of human well-being. For the total indicators selected by each participant, they ranged between 14 and 24 indicators. Despite the different goals and users of each participant´s tool, they all selected indicators to reflect potential impacts on the domains of affect, psychological well-being, education and community. Several other impacts on the other well-being domains were also identified driven by different points of views. Table 1 shows the tools involved in this study classified by their goals and stakeholders. Table 2 shows the twelve areas of impacts (well-being domains) and the indicators selected by the tool's creators to reflect impacts of their tools on human well-being. The two tables are followed by further explanations provided by the participants through post-activity discussions on why they made their selections. The level of detail in sections 4.1–4.12 is driven by the number of participants in each category of systems (e.g., several participants analysed LDCs provided more elaborations than one participant analysed CSCLS).

Table 1: Tools included in the study

Type of system / Service	Description / Goals	Users	Stakeholders
Learning Design Communities (LDCs)	Online community platforms with integrated lesson planning tools that support teachers in the creation, co-creation, and sharing of designs of learning activities. Teachers are also supported by data-driven systems that assist the lesson planning with data analytics and pedagogical guidelines.	Teachers	School community members (Teachers, learners, academic managers, families, other school staff)
Multimodal Learning Analytics (MLA)	Multimodal learning analytics to analyse learning environments with the objective of informing pedagogical design on how to improve face-to face collaborative learning physical spaces.	Teachers, Students	Schools, Universities, Educational technology researchers, architects
Computer-supported collaborative learning scripts (CSCLS)	A web-based tool that facilitates teachers to design and deploy computer-supported collaborative learning scripts based on the Pyramid pattern. The tool facilitates allocating students into multiple groups and for reaching a consensus for a given task following a Pyramid structure (phases in which the groups join into larger groups until the whole class comprises a single group). The tool provides a LA dashboard with actionable information to orchestrate the script.	Teachers, Students	Educational institutes, e.g., universities, schools, Online learning platforms, e.g., MOOCs

Tutoring system (TS)	A social media virtual companion with the aim of raising awareness to teenagers regarding a variety of dangers they can encounter in online platforms. By tackling issues like body image, social emotional learning or romantic relationships the teenagers will not only advance their digital literacy skills but also improve their social and emotional skills for online environments. The companion detects educational needs and triggers learning activities informed by LA.	Students (teenagers)	Educational institutions, schools' directors, teachers, parents, researchers
Classroom orchestration (CO)	An online classroom orchestration tool focused on emotional aspects that facilitates teachers in scaffolding student development of self-regulatory practices over time. The application focuses on supporting student development of self-awareness and self-management competencies which are critical to self-regulation and mental health.	Students, Teachers, Researchers, Professionals (trainers, instructional designers)	Educational Community including parents, administrators, policy makers; EdTech Community including enterprises
Citizens' learning community (CLC)	A learning community platform that follows a citizen science approach and gathers projects (called "missions"). It is a website where citizens can contribute to and learn from different investigations of different topics that other scientists have proposed.	Learners of citizens who want to contribute to science or are interested in a specific topic	Scientists that need a platform to collecting data, citizen in general

Table 2: Selections of indicators to reflect well-being impacts of the tools included in the study

Well-being domains (Impacted areas)	Selected indicators	Impacting tools
Life Satisfaction	Sense that one's life is the best to worst possible life for them at the time [29]	LDC, CO
	How satisfied are you with your life nowadays? [30]	LDC, TS, CO, CLC
	Satisfaction with life as a whole [31]	LDC, CSCLS, TS, CO, CLC
Affect	Positive affects: feeling happy, calm, peaceful. [32]	LDC, MLA, CSCLS, TS, CO, CLC
	Negative affects: feeling sad, stressed, anxious.[32]	LDC, MLA, CSCLS, TS, CO, CLC
Psychological well-being	Feeling that the things one does are worthwhile [30]	LDC, TS, CO, CLC
	Sense one is capable and good at what they do [32]	LDC, MLA, CSCLS, TS, CO, CLC
	Sense that one leads a purposeful and meaningful life [29]	LDC, CO
Community	Sense that one sees oneself as part of a community [30][31]	LDC, MLA, CSCLS, TS, CO, CLC
	Approximate total hours a month one was active in voluntary organizations [31]	LDC, CLC
	Sense that if one were in trouble, they would have relatives or friends they can count on to help them whenever they need them, or not [29]	LDC, CSCLS, TS
	Sense that most people can be trusted or that one needs to be very careful in dealing with people [31]	LDC, CSCLS, TS, CO,

	Satisfaction with relationships [30]	MLA, CSCLS, TS, CO
	Sense of discrimination in one's neighbourhood or community in one's neighbourhood [31]	MLA, CSCLS, TS, CO
	Proportion of persons victim of physical or sexual harassment, by sex, age, disability status and place of occurrence, in the previous 12 months [33]	MLA, TS
Culture	Engagement with / participation in arts or cultural activity [30]	LDC, CO, CLC
Education	Satisfaction with educational systems or schools in area in which one lives [34]	LDC, MLA, CSCLS, TS, CO
	Access to opportunities to learn [33]	LDC, MLA, CSCLS, TS, CLC
	Extent to which (i) global citizenship education and (ii) education for sustainable development (including climate change education) are part of teacher education; classroom curriculum and student assessment [33]	LDC, TS, CLC
	Average years of schooling [35]	CO
Economy	Decreasing the degree to which one is worried about losing their job or not finding a job [31]	LDC, TS
	Satisfaction with financial situation of one's household [31]	TS, CO
	Sense that the area where one lives is a good place to live for entrepreneurs forming a new business [33]	CO
	Material consumption [33]	TS, CLC
Environment	Satisfaction with efforts to preserve the environment [36]	LDC, CO, CLC
	How much (people) know about global warming or climate change [33]	LDC, CLC
Government	Sense there is freedom of assembly, demonstration, and open public discussion [37]	LDC, CSCLS, TS
	Print, broadcast, and / or internet-based media are not directly or indirectly censored [37]	TS
	Sense of confidence in government -national, local, civil service, judicial system, police, political parties. etc. [31]	LDC
	Satisfaction with one's last experience of public services [33]	LDC
	Sense there is respect for individual human rights nowadays in one's country [31]	LDC
Health	sense of having enough energy to get things done [38]	LDC, CO
	Projects to support parenting skills [39]	TS
	Sense that one's state of health is good [31]	TS, CO
	Lost workdays due to mental disorder or substance use [39]	TS, CO
	Suicide attempts [39]	TS, CO
	Number of persons who have seen a health professional during a year [39]	CO
	Healthy life expectancy [30]	CO
	Obesity in adults and adolescents [40]	TS
	Coverage of services for severe mental health disorders [40]	TS
Human settlements	Proportion of youth and adults with information and communications Technology (ICT) skills, by type of skill [33]	LDC, MLA, CSCLS, TS
	Proportion of population covered by a mobile network, by technology [33]	LDC, MLA, TS
	Access to internet at home [31]	LDC, MLA, CSCLS, TS
	Having a computer at home [31]	LDC, MLA, CSCLS, TS
	Having a cellular phone [31]	CSCLS, TS
Work	Satisfaction with job [34]	LDC, CSCLS
	Sense that current work life is interesting [34]	LDC, CSCLS

	Sense that one's supervisor has respect for and cares about one's welfare [41]	LDC, CSCLS
	Sense that one gets support and help from co-workers [42]	LDC, CSCLS
	Sense that the conditions of one's job allows one to be about as productive as one could be [41]	LDC
	Satisfaction with the balance between the time spent on the job and the time spent on other aspects of life [42]	LDC
	Satisfaction with opportunities for professional development and promotion in one's current primary job [31]	LDC
	Mechanisms for advice and concerns about ethics [43]	CSCLS

4.1 Life Satisfaction

Life satisfaction is defined as an overall assessment of feelings and attitudes about one's life at a particular point in time ranging from negative to positive [44]. As with all other domains, indicators to measure the impact on life satisfaction were selected for different reasons depending on the goals and users of each system. For the learning design communities included in this study, the participants agreed that their tools aimed at guiding teachers to achieve better lesson planning and facilitating the design of learning activities, which potentially would improve their feeling of being innovative and having done good work. This also applied to a lesser extent to the non-users stakeholders of these platforms, mainly students, who would benefit from lesson designs that may facilitate their learning process and therefore increase their overall satisfaction with life during a given period of time.

On another hand, the tutoring system's designers identified potential positive impact on this domain based on their system's capacity to support teenage school students in realizing and facing different threats they might encounter during their use of social media. As well as with the class orchestration tool, potential impacts were identified on its users' life satisfaction driven by the tool's support for the competences of self-regulatory, social awareness and experiencing life positively.

4.2 Affect

The domain of affect is defined to include positive and negative feelings, while the affect indicators are used to measure affect in the moment, or how a person is feeling in the moment, or a lasting emotional experience [27]. Similar to the responses on the life satisfaction domain, the competences related to self-regulation, self-awareness, self-management, and social awareness supported by both the tutoring and the orchestration tools were found to be influential to the users' affect.

The collaboration feature provided by several other tools in this study was one of the reasons of identifying potential positive and negative impacts on the domain of affect. While this point of view highlighted the feelings of happiness, calmness and satisfaction that can be derived from collaborative environments, it also referred to the negative feelings of anxiety, stress, and frustration that can be resulting from the feeling of being monitored, the need to contribute to the collaborative community, and the feeling of not being creative enough when exploring peers' work. Another perception of potentially impacting feelings of teachers and students by their use of the learning design communities assumed that helping teachers to create innovative designs for their students and facilitate their work planning (e.g. save time, increase of control), can lead to experiencing happiness and satisfaction for a given period of time.

4.3 Psychological Well-being

The domain of psychological well-Being is “the experience of life going well. It is a combination of feeling good and functioning effectively” [45]. The terms flourishing or eudaimonia is also used. All the participants identified possible direct and indirect impacts of their systems on the psychological well-being of their users and stakeholders, mainly teachers and students. For example, tools that aimed to offer teachers a better lesson planning should support both teachers and students with efficient and effective teaching and learning processes, which would eventually affect their feeling that what they do are worthwhile and they are good at it.

Another perspective from the tutoring system’s creators noted that both influencers and bulliers on social media can impact such aspects of the psychological well-being of their users, while this system may have positive impact in this regard by supporting its users for safer and more responsible use of social media. In the case of the orchestration tool, positive impacts on its users’ psychological well-being were also found to be gained and enhanced by emphasising competences like self-regulatory and social awareness.

4.4 Community

Community is defined as “a group of people living in the same place or having a particular characteristic in common” [46]. The participants identified and discussed several indicators to potentially inform their tools’ impacts on the community domain in senses of belonging, social support, community participation, and discrimination. The collaborative environment provided by the communities of learning design and the CSCL scripts tools was found a powerful mean to impact how a teacher or a student see herself as part of a well-organized and trustworthy community, and whether they would have other people (colleagues and mentors) they can count on to help them whenever they need them, or not.

The satisfaction with relationships among community members (i.e., students and teachers, students and students, teachers and teachers) was also found an indicator that reflect potential impacts of data-driven collaborative learning tools on their users’ well-being. In the same context, the aims of the tutoring and orchestration tools of facilitating their users’ development of social awareness and reducing social anxiety were found well-associated to community well-being indicators that measure how satisfied people are with their social relationships and how aware they are of potential harms (i.e. discrimination).

4.5 Culture

Culture is defined as “that complex whole which includes knowledge, beliefs, arts, morals, laws, customs, and any other capabilities and habits acquired by [a human] as a member of society [47]. The teachers’ engagement in design thinking activities supported by the lesson planning tools was found related to arts and cultural participation. Also, the reduction in social anxiety encouraged by the tutoring and orchestration tools would lead to more openness and therefore facilitate cultural participation.

4.6 Education

The domain of education encompasses formal education and lifelong learning. Formal education is defined as training typically provided by an education or training institution, structured and leading to certification”[48], while Lifelong learning is defined by as composed of people aged 25 or older in education and training [49]. The nature of the systems involved in this study as educational-oriented allows them all to influence this domain of well-being as part of their main objectives. For example, the outcomes of the learning design communities and

lesson planning tools would impact the satisfaction of the indirect users (students) with education provided by their schools and teachers. At the same time, these outcomes would also impact the lifelong learning of the direct users (teachers) by providing them with opportunities to learn from each other's work that is spread over several fields of knowledge, extending to global citizenship education and education for sustainable development, and backed by various innovative skills that can be shared.

4.7 Economy

Economy is defined as "the system according to which the money, industry, and trade of a country or region are organized." The domain of economy encompasses standard of living; economic equality and equity; jobs; natural resources, consumption and production; and business and entrepreneurship [50]. Some impacts were identified on this domain, particularly on the subdomain of standard of living. The teachers' use of learning design communities and lesson planning tools can help them increase their digital skills and empower them in their current profession, which potentially lead to decreasing the degree to which they are worried about losing their jobs or not finding a job. In this context, an assumption came from the creators of the tutoring system stating that the capacity of their system to teach users how to acquire new skills and keep clean digital footprints would help them for future job seeking. On a different level, the aim of the class orchestration tool to reduce users' negative affect and social anxiety was perceived to decrease value placed on social comparisons and then increase users' satisfaction on their financial situation.

4.8 Environment

The Environment is the natural world of land, sea, air, plants, and animals [50]; and it encompasses climate change, air, water, soil, and biodiversity [27]. Few impacts by the learning design communities and the citizens' learning community were pointed out on this domain, assuming that the users' knowledge on topics like climate change can be enriched when the learning designs and contents created and shared are related with the environment. Also, the users' satisfaction with efforts to preserve environment and their desire for more preservation were indicated to be impacted by using the orchestration tool, as decrease in negative affect and anxiety creates a greater awareness for future over immediate needs.

4.9 Government

Government is defined as the "economic, political and administrative authority and comprises mechanisms, processes and institutions, through which citizens and groups articulate their interests, exercise their legal rights, meet their obligations and mediate their differences [51]. The domain of government encompasses human rights, institutions, civic engagement, and trust [27]**.** As assumed with the environment domain, the learning designs and contents created and shared can also impact this aspect of well-being when they tackle topics like human rights. Other Indicators were selected to describe how the lesson planning tools may impact the satisfaction of students with the public service provided to them and their confidence in those who provide the service. In addition, the collaboration spaces in the communities of learning and learning design and the collective decision-making processes supported by the CSCL scripts were highlighted to be of a potential impact on users' well-being in their sense of freedom of assembly, demonstration, and open public discussion.

4.10 Health

Health is defined as “a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity” [52]. The intent of the class orchestration tool to increase positive moods and reduce negative ones was found impactful on its users’ sense of being in a good health state and having enough energy to get things done. The competences of self-regulatory, self-management and social awareness supported by this tool and by the tutoring system were also found relevant to realizing mental health needs and therefore reduce mental disorders and suicide attempts. Additionally, the reduction of social anxiety targeted by both tools may help their users of students, particularly adolescents, in dealing with the pressure social media puts on teenagers to conform to an ideal of beauty leading to problems like anorexia or body building.

4.11Human Settlement

Human settlements are defined as geographical areas where people live, composed of housing, food, transportation, and information and communications technology ICT [27]. Few Indicators were selected by the participants particularly to reflect impacts on the subdomain of ICT, like having a computer and access to internet, and improving digital skills.

4.12Work

Work is defined as an "activity involving mental or physical effort done in order to achieve a purpose or result [46] including both paid and unpaid work, while work well-being indicators cover aspects of workplace governance, workplace environment and work life balance [27]. Due to the aim of the learning design communities and lesson planning tools to support teachers in their professional practice, they were found to be impactful on several aspects of the work domain. For example, learning new pedagogical approaches and use of data analytics in education might affect teachers’ interest in their jobs, their access to opportunities for professional development, and their overall satisfaction with their work life. Since these tools were designed to support effective and efficient lesson planning tasks, they hold potential impacts on teachers’ productivity and balance between leisure and work time. Such tools, when they are provided by school leaders, can also affect the teachers’ feeling of being cared and supported by their supervisors to achieve better work results with proper spaces of independent work. The teacher collaborative environment supported by several tools and platforms in this study was also recognized impactful on the users’ sense of getting support and help from co-workers.

5 DISCUSSION AND CONCLUSIONS

The endeavour of LA research and practice to understand and improve learning and the environment in which it occurs can be extended to support various elements of human well-being. The current or future integration of LA into learning technologies can be optimized to not only understand learning and improve productivity (e.g. by tracking students’ performance), but also to capture and analyse relevant data that can help identify where these technologies increase or decrease human well-being for all the related stakeholders. To further investigate how learning technologies could impact well-being considering the promising and concerning roles of LA, we used the recently produced IEEE P7010 Well-being metrics to allow the digital well-being of selected educational tools to be more comprehensively tackled and evaluated. We asked the creators of ten learning technologies to clearly identify each tool’s goals, users, and stakeholders. Then they applied internal analysis

activities (e.g., projecting, hypothesizing, utilizing scenarios) to select indicators that could reflect their tools' positive and/or negative well-being impacts.

Despite the difference in the educational contexts, objectives, users and stakeholders of each tool in this study, possible impacts of all of them were identified on the well-being domains of affect, psychological well-being, community (i.e., sense of belonging), and education in both forms of formal education and lifelong learning. To a lesser extent, the domains of life satisfaction, work, and mental and physical health were highlighted to be potentially impacted by several tools. Few other impacts were identified on the well-being domains of culture, economy (i.e., standard of living), environment, human settlement (i.e., ICT) and government (i.e., sense of democracy). The focus of this study on only the creators of the tools represents a start point toward a systematic and iterative assessment process of each tool's digital well-being, wherein the conclusions coming from this activity must be supported by objective data collected from end-users and stakeholders; and to be used for guiding the design, development, implementation and monitoring of the tool to help safeguard human well-being.

Although the participants found the process useful to evaluate well-being impact (i.e., through their indicator selections and their answers on the Yes/No checklist and the post-activity discussion), they also indicated limitations and practical challenges of this approach. Many indicators were found irrelevant to the studied tools due to the nature of the IEEE P7010 standard that covers a wide spectrum of well-being areas that could be relevant to a wide range of A/IS. For example, non-selected indicators included 15 indicators that measure environmental well-being in dimensions of water, air, soil, and biodiversity; while the only two selected indicators in this domain were related to one's satisfaction with the efforts to preserve the environment, and one's knowledge about climate change. In addition, the well-being indicator selections were done based on an idealized/aspirational conceptualization of the tools (e.g., what they could possibly achieve in optimal conditions– both in terms of user adoption and tool development). As with many research prototypes, the provided indicators would be unlikely to provide meaningful insights unless the tool was widely adopted and used regularly.

Overall, this paper proposes an initial application of the IEEE P7010 recommended practice to conceptually investigate the well-being impacts of selected cases of LA-supported educational technologies. Both WIA methodology and the set of well-being metrics provided by the recommended practice are found promising to promote LA practices to especially increase student and teacher well-being. However, further research is needed, and much work remains to be done to further immerse the use of WIA in the field of LA.

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