Assessing the digital well-being of educational technologies supported by learning analytics

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To my parents
(Abushamlah and Hind)
&
To my wife and daughters
(Lubna, Hind and Alma)

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This thesis could not have been written without the sincere support of several individuals and groups over the last four years.

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Abstract

The accelerating adoption of digital technologies creates a direct relationship between the status of individual and societal well-being on one hand, and the state of the digital technologies that underpin human life experiences on the other. This technological shift is represented in the domain of Education by Technology-Enhanced Learning (TEL), a field of research and practice. The potential of technological advances to enhance learning has been well explored, as well as many of the challenges to the effective use of technology in education. Less research has been undertaken, however, on the ethical considerations related to TEL use and research. When data analytics are merged, which is present in TEL in the form of Learning Analytics (LA), the ethical concerns about the impact of digital technologies on human well-being become more relevant. This doctoral thesis aims at exploring indicators and methods that can support the assessment of the well-being impacts of LA-supported educational technologies. Value-sensitive design (VSD) methodology and elements of the IEEE P7010 Well-being Impact Assessment (WIA) were followed to achieve the objectives of this thesis. The term well-being was conceptualized in the TEL field through workshops with LA tool's developers and a systematic literature review, resulting in around 70 well-being indictors covering twelve life domains. The findings indicated that the well-being impact of TEL is more scoped in four main domains: affect, community, psychology, and education. Samples of users were consulted about the well-being indicators of two cases of LA-supported educational technologies, which were learning design community platforms and a computer-supported collaborative learning (CSCL) tool. Data collection scenarios were applied to enable the assessment of the CSCL tool on certain aspects of teachers' and learners' well-being, particularly teacher-perceived stress and students' basic psychological needs satisfaction. The findings shed light on how the tool's interface support the student's basis psychological needs of autonomy, relatedness, and competence, indicating that relatedness and completeness are more perceived by the students who participated in collaborative learning activities supported by the tool. The triggers of teacher-perceived stress when orchestration those activities were found to be either technological difficulties, actions by students or time-related issues.

Resumen

La adopción acelerada de tecnologías digitales crea una relación directa entre el estado del bienestar individual y social, por un lado, y el estado de las tecnologías digitales que sustentan las experiencias de la vida humana, por el otro. Este cambio tecnológico está representado el dominio del Aprendizaje mejorado con tecnología (TEL, por sus siglas en inglés), un campo de investigación y práctica. La investigació en TEL ha explorado extensamente el potencial de los avances tecnológicos para mejorar el aprendizaje, así como muchos de los desafíos para el uso eficaz de la tecnología en la educación. Sin embargo, ha realizado menos investigaciones sobre las consideraciones éticas relacionadas con el uso y la investigación de TEL. Cuando se fusiona el análisis de datos, que están presentes en TEL en forma de la analítica del aprendizaje (LA), las preocupaciones éticas sobre el impacto de las tecnologías digitales en el bienestar humano se vuelven más urgentes. Esta tesis doctoral tiene como objetivo explorar indicadores y métodos que puedan apoyar la evaluación de los impactos en el bienestar de las tecnologías educativas apoyadas por LA. La tesis siguie la metodología de diseño sensible al valor (VSD) y los elementos de la Evaluación de Impacto en el Bienestar (WIA) IEEE P7010 para lograr los objetivos de esta tesis. El término bienestar se conceptualizó en el campo TEL a través de talleres con los desarrolladores de la herramienta LA y una revisión sistemática de la literatura, lo que resultó en alrededor de 70 indicadores de bienestar que cubren doce dominios de la vida. Los hallazgos indicaron que el impacto de TEL en el bienestar tiene un mayor alcance en cuatro dominios principales: afecto, comunidad, psicología y educación. Se consultó a muestras de usuarios sobre los indicadores de bienestar de dos casos de tecnologías educativas apoyadas por LA apoyadas por LA. Estos casos consideran el uso de plataformas de comunidad de profesores para el diseño de aprendizaje y una herramienta de aprendizaje colaborativo apoyado por ordenador (CSCL). Se aplicaron escenarios de recopilación de datos para permitir la evaluación de la herramienta CSCL sobre ciertos aspectos bienestar de los docentes y los alumnos, en particular el estrés percibido por los docentes y la satisfacción de las necesidades psicológicas básicas de los alumnos. Los hallazgos

arrojan luz sobre cómo la interfaz de la herramienta respalda las necesidades psicológicas básicas de autonomía, relación y competencia del estudiante competencia del estudiante. Los resultados indican que los constructos de relación y competencia es percidio en mayor nivel por los estudiantes que participaron en las actividades de aprendizaje respaldaas por la herramienta colaborativa. Así mismo, los resultados indican que factores desencadenantes del estrés percibido por los docentes cuando organizaban esas actividades son fundamentalmente las dificultades tecnológicas, las acciones de los estudiantes o problemas relacionados con el tiempo.

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CHAPTER 1- INTRODUCTION

This chapter presents the research context of this dissertation, the overall aim and specific objectives, the derived research questions, the research methodology, the contributions, and limitations of this dissertation. The chapter also introduces the main studies conducted to achieve the dissertation's aim and a summary of the findings obtained. This dissertation is framed in the context of the potential impact of educational technologies supported by learning analytics on users' and stakeholders' well-being. It investigates well-being indicators that can be useful for reflecting such an impact and explores data collection scenarios that can contribute to the assessment of specific well-being aspects in educational technology cases. A Value-Sensitive Design methodology and elements from the IEEE P7010 standard for Well-being Impact Assessment were implemented to tackle the goal of this thesis. This chapter also includes the main conclusions, limitations, and implications for future work of this dissertation. The chapter concludes with an explanation of the structure of the thesis.

1.1. Introduction

Due to the wide-ranging use of the outcomes of Research and Innovation (R&I) processes in society, in addition to the growing role of Information and Communication Technology (ICT) in such processes, ethical questions concerning the impacts of R&I are increasingly critical (Reijers et.al., 2018). Technology-enhanced learning (TEL) is one of many research areas that have evolved as a result of the impact that ICT has on all domains of life. While a number of studies on the ICT area advocate for the inclusion of well-being as the impetus for improved ICT design (Choi et al., 2014; Pawlowski et al., 2015; Moqbel & Nah, 2017; Nurhas et al., 2021), a comprehensive understanding of the challenges and facilitators as to how well-being can be embedded in TEL research and design remains lacking.

There is widespread agreement that technological advances in education have the potential to enhance learning. Many of the challenges to the efficient use of technology in education are also widely known. However, less research has been conducted on the ethical considerations associated with TEL use and research. The increasing use of analytical approaches in educational technologies for the aim of understanding and promoting learning, i.e., Learning Analytics (LA), has increased the ethical burden associated with TEL research. The interdisciplinary field of LA borrows methods from Artificial Intelligence (AI) and goes together with other ICT and TEL research areas. Thus, the LA ethics discourse derives from wider discourses on computer ethics (Johnson, 1985) and AI ethics (Coeckelbergh, 2020; Siau, & Wang, 2020).

Since their inception, computers and digital technologies have sparked ethical concerns and debates about how these technologies support or undermine societal and human values and well-being. The Human Use of Human Beings (Wiener, 1954) is widely regarded as the seminal work in computer ethics, which provided a solid foundation for the computer ethics studies that came after (Bynum, 2000). The term *Computer ethics* was coined by Walter Maner in the late 1970s when he noticed, during teaching a medical ethics course, that new ethical considerations arise when computers are involved in medical ethics cases (Maner, 1978; Bynum, 2000). As defined by Maner (1978, 1996), computer ethics is that part of applied ethics concerned with ethical problems "aggravated, transformed or created by computer technology". By the end of the twentieth century, the field of computer ethics had exponentially grown, involving a wide range of disciplines, topics, scholars, research centers, university courses, conferences, textbooks, and articles (Wiener, 1954; Maner, 1978; Johnson, 1985; Bynum, 1985; Moor, 1985; Górniak-Kocikowska, 1996; Maner, 1996; Bynum, 1999; Johnson, 1999; Bynum, 2000; Cohen, 2000).

More recently, due to the massive presence of computational devices connected to the Internet and the expanding use of data analytics and AI techniques in numerous facets of life, a prominent discourse on ethics has emerged. As the field of AI (re)gained attention, new terms and subfields of research have raised since the mid-2010s to describe the ethics of AI, such as Responsible AI (Arrieta et al., 2020), Trustworthy AI (Floridi, 2019) and AI for good (Floridi et al., 2018), AI and the rights of the child (Mor, Craft & Hernández-Leo, 2013; Hernández-Leo, 2022). Stahl (2022) discussed the relationship between the two discourses of computer ethics and ethics of AI and compared their scopes (technologies they cover), the topics and issues they discuss, their theoretical basis and reference disciplines, the solutions, and mitigations options they propose, and their societal impact.

Both discourses of computer ethics and ethics of AI have progressively covered topics and issues related to all aspects of life where computers and AI have an impact on individuals or societies. While many computer ethics topics, such as privacy, data protection, and intellectual property, have generated societal and therefore political attention, they never led to including the computer ethics terminology into public policy discourse (Stahl, 2022). This is not the case for AI ethics, which is not only a flourishing academic debate but is expressly addressed by various policy proposals (Rodrigues, 2020; Stahl, 2022). The vast amounts of data needed for training and validating AI models and the opacity of such processes have raised questions not only about data privacy and protection (Dilmaghani, Brust, Danoy, Cassagnes, Pecero & Bouvry, 2019), but also about lack of transparency (Lepri, Oliver, Letouzé, Pentland & Vinck, 2018; Dörr, & Hollnbuchner, 2017), bias (Crawford, & Schultz, 2014), accountability (Shewbridge, Fuster, & Rouw, 2019), discrimination (Ferrer, van Nuenen, Such, Coté & Criado, 2021) fairness (Yang & Stoyanovich, 2017), and the potential to promote or undermine well-being (Schiff, Ayesh, Musikanski & Havens, 2020). Consequently, the AI scientific community and policy makers are currently engaged in global efforts resulting in a corpus of work codes of conduct, ethical frameworks, and recommended practices that can aid and inspire technologists and researchers from various disciplines in integrating human values to their data-driven technology designs.

Positive or negative, AI’s impacts on human well-being are more nuanced than is commonly believed (Schiff et al., 2020). Technologists often overlook the multidimensionality of well-being in favor of economical valuation or a single aspect of well-being. For example, a site-based study has revealed that engineers are frequently more concerned with the physical harm that a single product may inflict than with social, emotional, or economic problems (Vakkuri, Kemell, Kultanen, Siponen, & Abrahamsson, 2019).

And though the LA community is becoming increasingly concerned about ethics, the societal principles defining the concept of Responsible AI have been explored only to a limited extent and are scattered across LA research, with the majority of cases focusing on transparency (See Appendix A). Yet, studies assessing LA systems from an ethical perspective should take a more all-encompassing criteria, one that goes beyond mere transparency to take into consideration the multitude of ways in which LA systems impact human well-being beyond learning outcomes. Thus, the endeavour to holistically investigate and assess the impacts of LA-supported educational technologies on well-being reflects the overall aim of this thesis.

We posit that impact assessments provide a promising strategy for achieving the research aim. Examples of areas where impact assessments have been employed in the past involve human rights (Latonero, 2018), regulatory settings (Radaelli, 2009), algorithms and AI (Reisman, Schultz, Crawford & Whittaker, 2018; Calvo, Peters & Cave, 2020). We focus specifically on the recently published IEEE P7010-2020 standard created to assess AI's impacts on human well-being (Schiff, Ayesh, Musikanski & Havens, 2020; IEEE, 2020). We argue that the well-being metrics like those provided by IEEE P7010-2020 standard could be adopted by educational technologists pursuing responsible LA development.

1.2. Theoretical framework

The theoretical framework of this dissertation considers the two main areas of knowledge outlined below.

Section 1.2.1 provides an overview on TEL as a field of research and practice. It also discusses the presence of data analytics in the domain of education in the form of LA. The section elaborates on the promising and concerning roles LA can play when integrated to educational technologies.

Section 1.2.2 discusses the term well-being and how the research on the impact of digital technologies on well-being has been increasingly debated in several contexts using various terminologies. In this research, the term "digital well-being" is used to describe the impact of digital technologies on any aspect of user well-being.

1.2.1. Technology Enhanced Learning

Technology-Enhanced Learning (TEL), among other terminologies such as Educational Technology or Learning Technologies, refers to the use of ICT in teaching and learning (Kirkwood & Price, 2014). The term TEL was originally adopted in Europe and inspired the naming of programs for research funding, a conference (the European Conference on Technology-Enhanced Learning), and a association (the European Association of Technology-Enhanced Learning).

Several researchers have demonstrated the effectiveness of TEL applications in enhancing learning outcomes (Tamim et al, 2011; Cheung, 2012; Cheung, 2013; Schmid et al., 2014; Xu et al., 2019). Examples of TEL applications include learning management systems (LMS) (Turnbull, Chugh & Luck, 2020), computer assisted instruction (CAI) (Fletcher-Flinn & Gravatt, 1995; Bayraktar, 2001), classroom-based technologies such as interactive whiteboards, integrated learning design tools (Hernández-Leo, Asensio-Pérez, Derntl, Prieto & Chacón, 2014; Hernández-Leo et al., 20 18), computer-supported collaborative learning (CSCL) Fischer et al., 2007) and learning analytics (LA). The following paragraphs focus on the latter three applications as they represent main examples of the TEL cases we study in the coming phases of this thesis.

Learning design is the study of methods and strategies to assist teachers in developing suitable learning activities for their students (Hernández-Leo, D, Martinez-Maldonado, Pardo, Muñoz-Cristóbal & Rodríguez-Triana, 2018). By mapping learning objectives and activities, the field of learning design has generated computer-assisted methodologies and tools to support teachers in the creation of pedagogically-sound learning environments (Mor, Craft & Hernández-Leo, 2013). For example, online learning design communities provides a collaborative space to (co)design, share, explore, reuse and comment learning designs at different levels of granularity, pedagogies, and phases of design, in diverse representations (Hernández-Leo, Asensio-Perez, Derntl, Prieto, & Chacon, 2014).

Computer-Supported Collaborative Learning (CSCL) refers to an effective educational strategy in which learners interact with others to achieve learning goals while developing shared knowledge (Fischer et al., 2007). Teachers are increasingly using computer-supported learning in their classrooms to facilitate complex tasks such as student collaboration. Therefore, teachers play an important role in monitoring and fostering the types of interactions between students that are favourable for learning (Gillies, Ashman & Terwel, 2007). Several models and technological tools have been presented in the CSCL field (Manathunga & Hernández-Leo, 2018; Schwarz, 2018; Inaba & Ando, 2015). Scripts have been suggested as a technique to structure collaboration in TEL scenarios by providing instruction on how to work collaboratively (Hernandez-Leo et al., 2005 & Hernandez-Leo et al., 2010). These scripts are referred to as Collaborative Flow Patterns (CLFPs). In collaborative learning contexts, teachers often use CLFPs to structure manage the flow of various learning activities (Hernandez-Leo et al., 2005). The pyramid pattern is an example of a CLFP that can be used in collaborative educational environments when a group of participants are required to solve the same complex problem for which there is no unique answer (HernándezLeo et al., 2006). Using LA tools like dashboards can support teachers in monitoring and fostering the types of interactions between students that are favourable for learning (Van Leeuwen et al., 2014; Alavi & Dillenbourg, 2012; Dimitriadis, 2012).

The Society for Learning Analytics Research (SoLAR) (Lang et al., 2017) defines LA as "the measurement, collection, analysis, and reporting of big data about learners and their contexts and behaviors, for purposes of understanding and optimizing learning and the environments in which it occurs" (Siemens & Long, 2011, p. 33). Several studies have proposed LA interventions to support teachers (Alavi & Dillenbourg, 2012; Mercier, 2016; Slotta et al., 2013; Schwarz, 2018). For example, an instructor's tablet was developed by Slotta et al. (2013) to enable teachers to manage learning activities based on the performance of the group. Thus, the use of LA in the CSCL field can support both teachers and students in the classroom (Van Leeuwen et al., 2014; Alavi & Dillenbourg, 2012; Dimitriadis, 2012).

When considering the positive impact that LA may have on learning, it is important to keep in mind that its ethical issues are not far behind. According to Mougiakou et al (2023), ethical considerations in LA refer to "systemising, defending, and recommending concepts of right and wrong conduct in relation to data; they are considerations that tackle the potential for data misuse, and issues about the right, legitimate, and proper ways to use data" (p. 145). LA researchers (Hoel, Griffiths & Chen, 2017; Prinsloo & Slade, 2017) have used existing policy frameworks for data privacy and protection by breaking them down into design principles for LA systems. Other frameworks have been proposed to address data-cantered ethical considerations in the adoption of LA, including privacy concerns and extending to societal values like as transparency, trust, fairness, and accountability (Shum, 2017; Chen & Zhu, 2019; Gardner, Brooks & Baker, 2019; Drachsler & Greller, 2016). However, there is a research void about how to comprehensively analyse the impact of LA-supported educational technologies on the well-being of students and teachers. In a literature review (Hakami & Hernández-Leo, 2020) that explored the presence of the four values of fairness, accountability, transparency and well-being in the papers published in the ACM Learning Analytics and Knowledge (LAK) conference from 2011 to 2020 (LAK11 to LAK20), we found that 75% (36 out of 49 papers that included one or more of the four values) mentioned the term transparency, while only 7 papers (14%) mentioned the term "well-being" (See Figure 1 and Appendix A).

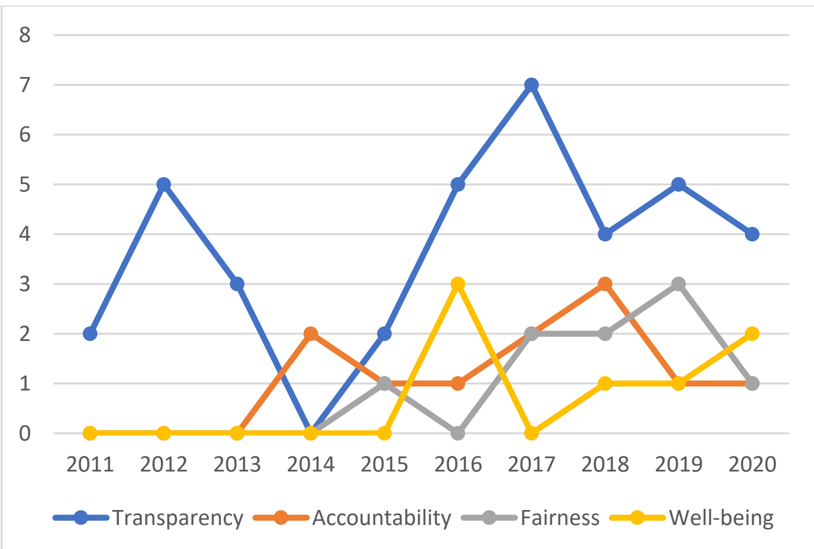

Figure 1. Papers that tackled the terms fairness, accountability, transparency, and well-being in LAK conference from 2011 to 2020

1.2.2. Digital Well-being

The inextricable connection between Individual and social well-being on the one hand, and the state of today's information environment and the digital technologies that facilitate our interactions with it on the other, raises grave ethical concerns regarding the impact of such technologies on well-being that must be addressed (Floridi, 2014; Burr, Taddeo & Floridi, 2020). Digital well-being is often defined by juxtaposing it against undesirable phone habits, although the concept of general well-being is not understood as the absence of an undesirable state (Abeele, 2021). As the term digital well-being is used in this thesis to describe the impact of digital technologies on human well-being (Burr, Taddeo & Floridi, 2020), defining well-being itself is a key.

Traditionally, well-being has been a subject of philosophical research, but in recent decades, it has become a crucial topic in other disciplines, notably psychology and economics (Brey, 2012). There is yet to be an agreed-upon, universal definition of what "wellbeing" means (Osman & Ismail, 2019). A wide range of well-being definitions and metrics based on the specific setting is being presented and discussed. While some definitions focus solely on the respondents' health or feelings, others focus on their cognitive judgments, and yet others focus on objective quality of life components, resulting in many different things get called 'well-being' (Diener, 2009).

The construct "well-being" refers in this research to the sum of one's positive functioning and being, signifying something "good" after accounting for setting and context (Floridi 2014; Wissing, 2022). Therefore, there is a far wider spectrum of states and experiences that build up human well-being than one or two dimensions, e.g., psychology and health. A more multidimensional conceptualization for well-being is provided by Maggino (2016) as: "A good and healthy society is that in which each individual has the possibility to participate in the community life, develop skills, abilities, capabilities and independency, adequately choose and control his/her own life, be treated with respect in a healthy and safe environment and by respecting the opportunities of future generations".

Through the Global Initiative on Ethics of Autonomous and Intelligent Systems A/IS, the Institute of Electrical and Electronics Engineers (IEEE) explores such weighty ethical concerns, with the stated goal of ensuring "a positive impact of A/IS on human well-being, while minimizing the risk of unintended negative outcomes" (IEEE, 2019). In response, a set of guidelines called IEEE Recommended Practice for evaluating the Impact of Autonomous and Intelligent Systems on Human Well-Being (IEEE, 2019) was published. This IEEE body of work includes a well-being definition (framed within the goals of Ethically Aligned Design): "well-being refers to an evaluation of the general quality of life of an individual and the state of external circumstances" and "it encompasses the full spectrum of personal, social, and environmental factors that enhance human life and on which human life depend" (IEEE, 2019).

Yet, the challenge is that these definitions are still too wide and overarching to inform technology design and evaluation. Meeting such an objective will need defining distinct well-being domains and indicators to highlight the notion of well-being for each scenario, which will lead to a deeper understanding of digital well-being.

National and international agencies and governments are utilizing subjective and objective indicators to better understand well-being within nations and country sub-populations with various aspects of life. Subjective well-being indicators are used to collect data on how individuals perceive their level of well-being. Subjective indicators include measurements for the domains of life satisfaction, affect, psychological well-being, economy (e.g., earnings satisfaction), community (e.g., sense of safety, loneliness), etc. (IEEE, 2020). Research supports the use of subjective indicators, including those based on questionnaires, surveys, polls, and other subjective data collection methods. Subjective indicators which meet rigorous scientific standards are considered valid and reliable measures within the scientific community (OECD, 2017; Pavot & Diener, 1993; Frey & Luechinger, 2007; Ovaska & Takashima, 2006). Income, productivity, employment status, education, life expectancy, hours worked per week, and other measures are examples of objective indicators. Such indicators have been used to better understand the factors that allow countries and populations to flourish. Examples of subjective and objective indicators in use are the OECD**'s** Better Life Index and the World Happiness Report**s**.

Drawing from subjective and objective well-being indicators, the IEEE P7010 standard provides a set of indicators that is sufficiently comprehensive to cover a wide range of data-driven technologies and their potential impact on twelve well-being domains: satisfaction with life, affect (feelings), psychological well-being, community, culture, education, economy, environment, government, health (physical and mental), human settlement, and work (IEEE, 2020).

1.3. Thesis Objectives

The theoretical framework of this research has positioned it in the intersection of the research areas of human well-being and the subfield of digital well-being on one hand, and technology-enhanced learning and the subfield of learning analytics on the other hand. Based on the research challenges in this context, the general objective of this thesis is *to contribute to the operationalization of the assessment of well-being impacts of educational technologies supported by learning analytics*.

Realizing the broadness and complexity of well-being assessment in TEL and LA contexts necessitated breaking down the main objective into three specific objectives, each of which to be tackled through groups of questions with narrower emphasis.

The first objective is to identify well-being indicators that conceptualize and initially identify the impacts of LA-supported educational technologies on well-being. It also explores the effectiveness of using the IEEE P7010-2020 well-being metrics by LA researchers in increasing their awareness of well-being domains and indicators, and therefore their capacity to address these indicators as principles of design.

The second objective is concerned with the data collection scenarios that can contribute to the assessment of the impacts of specific LA-supported educational technology cases on well-being aspects.

The third objective is to offer examples on the possible impacts of LA-supported educational technologies on well-being aspects from users' perception (Figure 2). The tools mentioned in the research questions are clarified in Table 1.

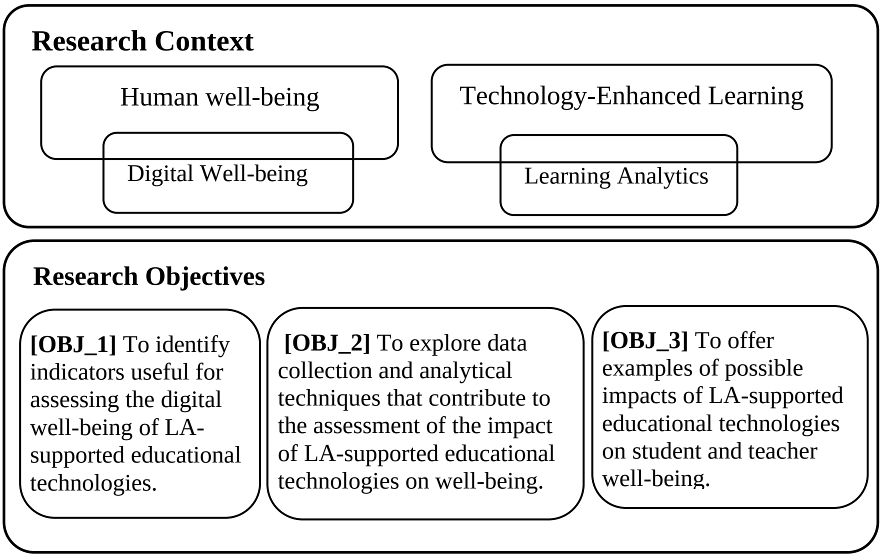

Figure 2 Thesis context and objectives

[OBJ_1] To identify indicators useful for assessing the digital well-being of LA-supported educational technologies.

Researchers and experts all around the world have spent decades formulating indicators that can be used to assess and measure well-being (Maggino, 2016). The impact of LA-supported educational technologies can be delineated by subjective and objective indicators that are already being in use to measure well-being, i.e., scientifically valid. However, because such indicators are contextual and span many life domains, including them all as design principles for educational technologies would be a precipitate approach. A set of well-being indicators that considers the objectives and users of LA-supported educational technologies is essential to assess their digital well-being. The following group of questions explores useful indicators that consider positive and/or negative well-being implications in TEL and LA research, as well as the usefulness of IEEE P7010-2020 well-being metrics by LA in increasing LA researchers' awareness of the digital well-being of their designs.

RQ1.1 Where and how can LA-supported educational technologies impact well-being?
RQ1.2 How much and in which circumstances/areas is the term well-being used in TEL research?
RQ1.3 To what extent does the use of IEEE P7010-2020 well-being metrics increase the awareness of educational technologists about their tools' well-being impact?

Table 1 Descriptions of the tools under study in the research questions of OBJ2 & OBJ3

Tool	**Description**	**Related OBJ**	**Related RQ**
Integrated Learning Design Environments (ILDE)	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.	OBJ3	RQ3.1
PyramidAPP	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.	OBJ2, OBJ3	RQ2.1, RQ2.2, RQ2.3, RQ3.2, RQ3.3, RQ3.4, RQ3.5,
ANALYZE	A web-based tool that provides different dashboards about students' progress and students' activities with exercises and videos in the Open edX platform.	OBJ2	RQ2.1
Teacher Action Planner (TAP)	TAP is aimed at providing an actionable dashboard for teachers to manage design and orchestration (or even design) of science inquiry activities that are carried out with the WISE system.	OBJ2	RQ2.1

[OBJ_2] To explore data collection and analytical techniques that contribute to the assessment of the impact of LA-supported educational technologies on well-being.

Critically, assessing impacts requires not just conjecturing about them, but measuring them (Schiff et al., 2020). Since well-being is measurable (OECD, 2017; IEEE, 2020), we assume that measuring well-being aspects of individuals during the use of digital technologies is achievable as well. Measuring what is good and bad for well-being allows technologists to manage positive and negative impacts on well-being (IEEE, 2020). Based on the cases investigated in the previous phase (i.e., OBJ_1), this objective is traced through narrower well-being scopes in specific cases, e.g., positive feelings in ANALYSE and TAP, students' basic psychological needs satisfaction and teacher-perceived stress in PyramidApp.

RQ2.1 What data collection and analytical techniques are useful to study affective well-being in the use of ANALYZE, TAP and PyramidApp?
RQ2.2 How valid is METUX TENS-Interface questionnaire as an instrument for measuring students' psychological well-being in the use of PyramidApp?

[OBJ_3] To offer examples of possible impacts of LA-supported educational technologies on student and teacher well-being.

The indicators and measures discovered in the previous phases of the used methodology are applied to study the impact of two cases of LA-supported educational technologies on student and teacher well-being. The first case is ILDE (Hernández-Leo, Asensio-Pérez, Derntl, Prieto & Chacón, 2014; Hernández-Leo et al., 2018), learning design community platforms with integrated lesson planning tools that support teachers in the creation, co-creation, and sharing of designs of learning activities. A questionnaire driven from scientifically valid well-being indicators across twelve well-being domains was developed to explore teachers' perceptions about the impact of ILDE on their well-being. The second case is PyramidApp (Manathunga & Hernández-Leo, 2018), a web-based tool that facilitates teachers to design and deploy computer-supported collaborative learning scripts based on the Pyramid pattern. The impact of PyramidApp on students' and teachers' well-being was preliminarily explored by engaging the tool's developers and samples of users and stakeholders in surveys and interviews guided by the first activity of IEEE P7010 standard. Based on the results gained, more specific research questions were formulated to investigate PyramidApp's impact on specific aspects of well-being, i.e., student psychological well-being and teacher perceived orchestration stress.

RQ3.1 How do teachers perceive the impact of ILDE on their well-being?
RQ3.2 What are the possible impacts of PyramidApp on learner and teacher well-being?
RQ3.3 To what extent are the students' basic psychological needs of competence, relatedness and autonomy are satisfied by PyramidApp's interface?
RQ3.4 What are the triggers of teacher-perceived stressful moments when orchestrating collaborative learning using PyramidApp?
RQ3.5 What orchestration actions can be related with teacher-perceived stressful moments when orchestrating collaborative learning using PyramidApp?

1.4. Research methodology

Practicing ethics in R&I, also known as Responsible Research and Innovation (RRI), can be formulated as project-specific codes of conduct and principles of design; ethicists' involvement in the design processes of technology; and stakeholders' engagement with ethical challenges in collaborative settings (Reijers, et.al., 2018). This research posits that engaging experts and stakeholders in the process of selecting valid well-being indicators can be useful as a start point towards principles of LA design by which well-being is safeguarded. A well-established methodology for practicing ethics in ICT research is Value-Sensitive Design (VSD) (Friedman, 1996; Friedman, Kahn, & Borning, 2006), which consists of conceptual, empirical, and technical investigations on how a technology design can consider human and societal values. Based on the VSD three levels of investigation, the IEEE P7010 Well-being Impacts Assessment (WIA) provides guidelines scoped to aligning the multidimensional value of well-being to technology development (IEEE, 2020).

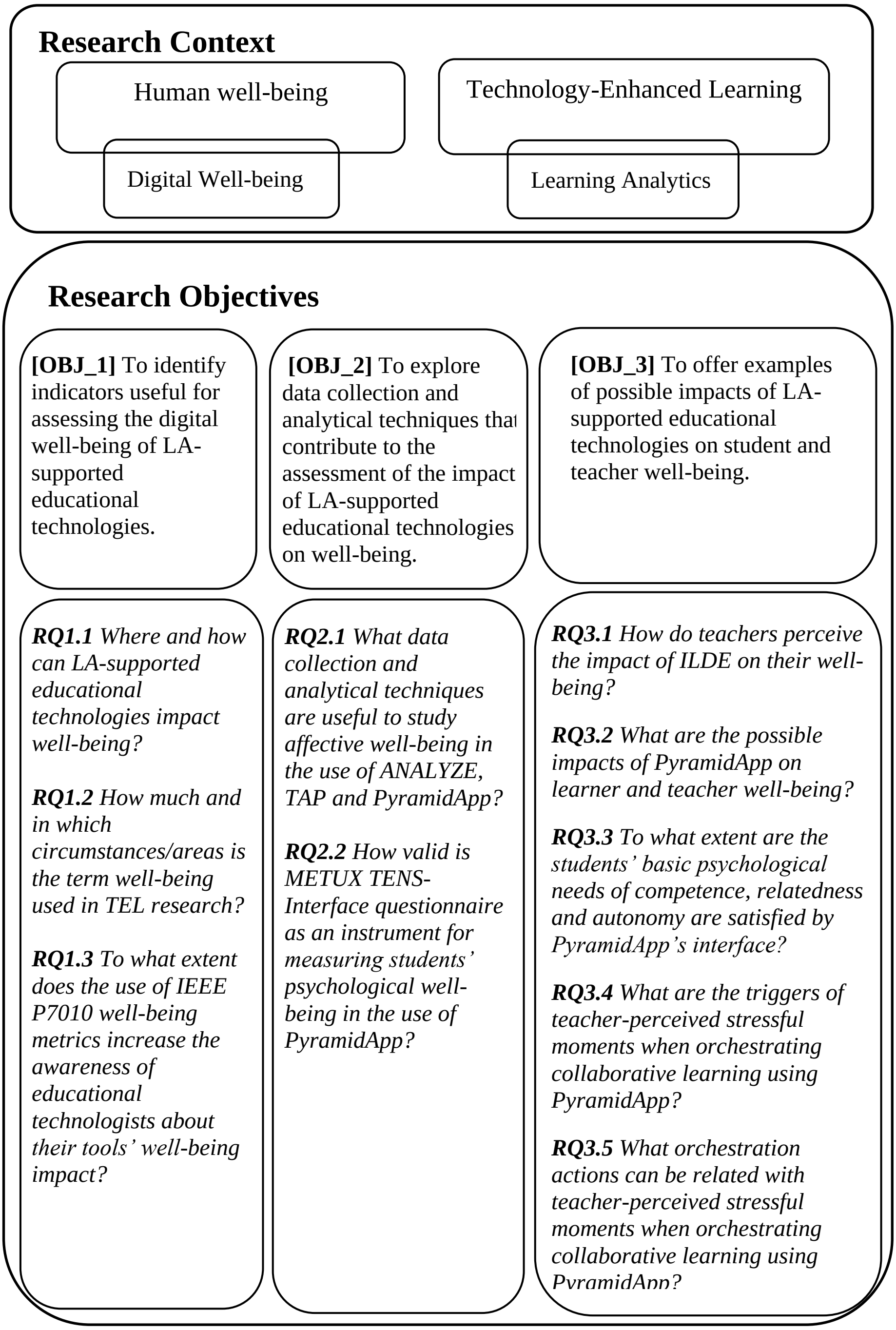

Figure 3 Schema of research context, research objectives and specific research questions

1.4.1. Value Sensitive Design (VSD)

The term “value” in this methodology refers to “the principles or standards of a person or society, the personal or societal judgement of what is valuable and important in life.” Value Sensitive Design (VSD) is a theoretically grounded approach to technology design that considers human values throughout the design and evaluation processes in a principled and comprehensive manner (Friedman, Kahn, & Borning, 2006). Value Sensitive Design is founded on an iterative methodology that combines conceptual, empirical, and technical investigations (Figure 4).

Conceptual investigation. Under the rubric of conceptual investigations, VSD takes up questions such as: Who are the direct and indirect stakeholders affected by the design at hand? How are both classes of stakeholders affected? What values are implicated? How should we engage in trade-offs among competing values in the design, implementation, and use of information systems (e.g., autonomy vs. security, or anonymity vs. trust)? (Friedman, Kahn, & Borning, 2006).

Empirical investigation. Any human behavior that can be observed, measured, or documented is susceptible to empirical investigation. Therefore, the entire spectrum of quantitative and qualitative methodologies employed in social science research may be applicable here, involving observations, interviews, questionnaires, experimental manipulations, collection of relevant documentation, and measures of user behavior and human physiology. Examples of the questions that might be the focus of VSD empirical research are: How do stakeholders perceive individual values in the interactive context? How do they rank competing values in design compromises? How do they prioritize personal values and usability factors? (Friedman, Kahn, & Borning, 2006)

Technical investigation. In one form, technical investigations focus on how existing technological features and mechanisms support or undermine human values. In another form, technical investigations entail the proactive design of systems to support the values specified in the conceptual investigation. In this thesis, the technical investigation is focused on the first form, where the well-being impact of existing LA-supported educational technologies are studied in the conceptual and empirical phases. VSD technical investigation can also include the exploration of analytical techniques useful for tackling the values identified in previous phases.

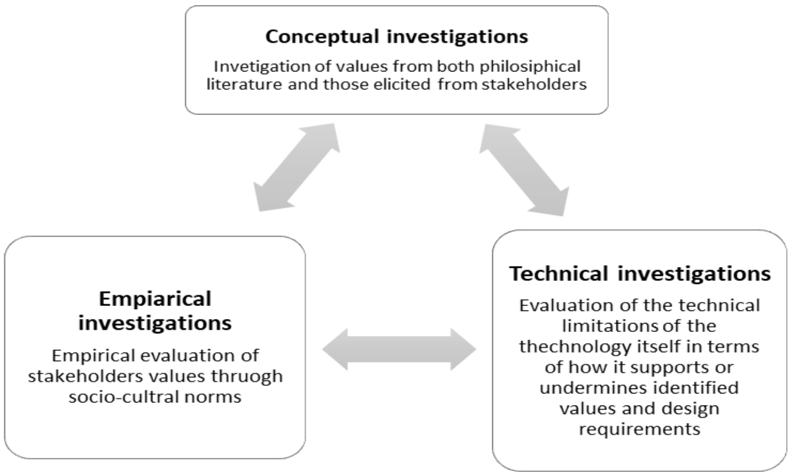

Figure 4. Phases of Value Sensitive Design (VSD) methodology

1.4.2. IEEE P7010-2020 Well-being Impact Assessment (WIA)

The recently produced IEEE 7010-2020 Recommended Practice for Assessing the Impact of Autonomous and Intelligent Systems on Human Well-Being offers a set of well-being indicators and a systematic approach based on the VSD methodology for gaining a multidisciplinary understanding of how intelligent and autonomous systems (A/IS) may benefit human well-being from several viewpoints (IEEE, 2020). The IEEE P7010 Well-being Impact Assessment (WIA) is an iterative process composed of five main activities: 1) Internal analysis and user/stakeholder engagement, 2) the creation of a well-being indicators dashboard, 3) the creation of a data collection process and the data collection, 4) data analysis and the use of said data to improve the technology in question, and 5) iteration.

The application of WIA approach to a given case implicates the three phases of investigation in VSD methodology. In the conceptual phase, the system's objectives and users are identified, well-being domains and indicators to reflect well-being impacts are selected by the tool's developers. At the empirical level, users and stakeholders of the tool under investigation are engaged to reflect on the selected well-being indicators for better understanding on how the tool can impact their well-being. Also at the empirical level, data collection plans are set, and well-being data is collected to continuously evaluate the tool's impact on well-being. The technical investigations are conducted either to facilitate the process of gathering well-being data, or to modify the tool based on the gathered data; or both.

We argue that applying the first activity of WIA methodology to LA-supported educational technologies, regardless of being intelligent or autonomous, can be justified. The first activity of WIA is concerned with conceptualizing the areas of well-being impacts of a certain product through the selection of well-being indicators associated with the *use* of the product under study. This product can be a chatbot, an autonomous car or any A/IS across all life disciplines. At the first level of WIA methodology (i.e., internal analysis), the intelligent capabilities of the tool under study are not as relevant as how it is being used and by whom. For example, the discussion around autonomous cars is mostly focused on their potential to save lives, while WIA approach urges developers to consider other well-being metrics linked to the use of cars, such as greenhouse gas emissions and work-life balance. The first activity of WIA is equivalent to the VSD conceptual investigation, where the focus is on the impacts derived from using a technology. In WIA, this conceptual investigation is facilitated by a wide-ranging set of subjective and objective well-being indicators already being in use by governmental and non-governmental indexes of nations' well-being and happiness (i.e., scientifically valid). The latter activities of WIA are more concerned with aligning the intelligent and autonomous capabilities of A/IS to measure and support users' well-being and mitigate potential harms. Thus, the use of WIA in this thesis is limited to the initial phase that fulfills VSD conceptual investigation, while not contradicting with LA-supported educational technologies that are less autonomous and intelligent. For VSD empirical investigation that is represented in the latter phases of WIA by creating a developer-facing dashboard, visualizing well-being data captured with the help of the A/IS competencies, this thesis follows mixed-method approaches that are less automated, yet compatible to the context of LA-supported educational technologies.

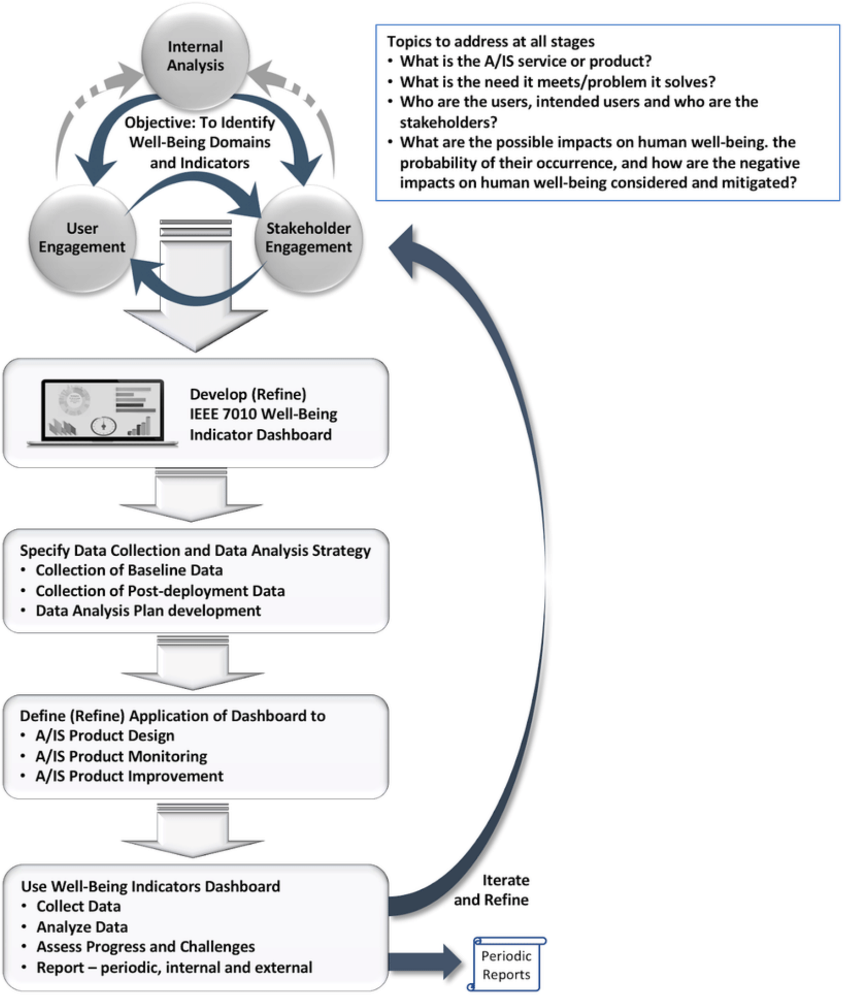

Figure 5 Flowchart of the iterative and adaptive nature of the IEEE P7010 WIA, Taken from (IEEE P7010, 2020)

1.4.3. VSD Implementation

To achieve the objectives of this thesis, VSD conceptual, empirical, and technical investigations were adapted to address precisely the values that are under the umbrella of the multidimensional value of well-being.

To conceptualize the term well-being in the neighboring contexts of TEL and LA, two workshops guided by the IEEE P7010 WIA first activity, i.e., internal analysis, were systematically conducted to identify well-being domains and indicators that can be relevant to multiple TEL and LA cases. The workshops involved 22 LA researchers who initially assessed the well-being impact of 16 cases of LA-supported educational technologies represented by 22 tools. In addition, we conducted a systematic literature review on well-being and TEL for the purpose of identifying the contexts and circumstances of well-being studies in TEL research. The questions we take up in the VSD conceptual investigation in the sense of well-being are like: “What well-being aspects are implicated in the use of LA-supported educational technologies?”, “How are the stakeholders’ well-being and societal well-being affected by the use of LA-supported educational technologies?”.

VSD empirical investigations were conducted in two levels. First, users from two cases (i.e., ILDE and PyramidApp) were surveyed and interviewed to consult their views on the developers’ assumptions of how these two tools can impact well-being. Second, subjective, and objective measurements were applied to study distinct well-being aspects in the use of PyramidApp. Examples of questions we ask in VSD empirical phase are: How do teachers perceive the impact of ILDE on their well-being?” and “To what extent does PyramidApp satisfy the students’ basic psychological needs of competence, relatedness, and autonomy?”.

VSD technical investigations were partially achieved in this research through investigating the well-being impact of existing tools and services through collecting subjective and objective data from developers, users, and stakeholders in the previous two cases.

1.4.4. Methods

Quantitative and qualitative data gathering techniques were conducted to answer the research questions. To facilitate the IEEE P7010 internal analysis process (i.e., equivalent to VSD conceptual phase), a mixed-method survey (see appendix D) and interviews were used with LA researchers (i.e., tools’ developers) in two occasions. Samples of users of two cases (i.e., ILDE and PyramidApp) were engaged in questionnaires and interviews to reflect on the IEEE P7010 well-being indicators selected by the tools’ developers. Furthermore, a systematic review of the literature on well-being and TEL was carried out to determine the settings and conditions of well-being studies in TEL research.

Table 2 Research methods ordered by appearance in the thesis

Publication*	Data gathering technique	Data source	Purpose
C1	Survey, interviews	Researchers (n=12)	To identify well-being indicators related to LA cases
C2	Systematic literature review	Papers (n=43)	-To look further into the uses of the term well-being in TEL papers, its formulated expressions, conceptualizations, and areas of impact
J1	Survey, co-design workshop	Researchers (n=10) Researchers (n=6)	-To identify well-being indicators related to LA cases -To initially define of analytical techniques to measure positive feelings, -To examine the usefulness of IEEE 7010 standard in TEL contexts
C3	Survey	Teachers (n=68)	-To investigate the possible well-being impacts of learning design community platforms from the perspective of the intended users of such tools, i.e., teachers
C4	Survey, interviews	Researchers (n=2) Teachers (n=2) Students (n=25)	-To investigate the possible well-being impacts of PyramidApp, a CSCL tool, from the perspective of its developers and intended users, i.e., students and teachers
C5	Survey	Students (n=53)	To explore how PyramidApp satisfies the students' basic psychological needs of competence, autonomy, and relatedness.
S1	Survey	Teachers (n=5)	- To understand the triggers of teacher-perceived stressful moments when orchestrating collaborative learning with technology

**J: journal article; C: Conference paper; W: Workshop paper; S: submitted (or about to be submitted) manuscript*

Analytical methods for measuring specific aspects of well-being in TEL and LA contexts were initially explored via a codesign workshop. Psychological well-being of student users of a CSCL tool was measured through a survey based on Self-determination

Theory (Deci & Ryan, 1985; Ryan, 1995; Ryan & Deci, 2000; Ryan & Deci, 2008; Ryan & Deci, 2017). Multimodal data (i.e., screen and video recordings, log data, and observation notes) was collected and preliminarily analysed to quantify the orchestration load of teacher users of PyramidApp. Finally, a mixed-method survey was developed and used to understand the triggers of teacher-perceived stressful moments when orchestrating collaborative learning with technology and explore the orchestration actions associated with these triggers. Table 2 shows a summary of the studies conducted throughout this research, explaining studies' goals, participants, data gathering techniques and associated publications.

1.5. Contributions

1.5.1. Contributions

The main contributions of this work are related to the three specific research objectives undertaken in this dissertation (Figure 6).

The first set of contributions (Figure 7) can be categorized under the aim of identifying well-being domains and indicators that can help in conceptualizing well-being in the context of LA-supported educational technologies.

The second group of contributions (Figure 8) are related to the data collection scenarios that can support measuring aspects of student and teacher well-being when using educational technologies, particularly students' psychological well-being and teacher-perceived stress when using PyramidApp, a CSCL tool.

The last set of contributions (Figure 9) are related to assessing aspects of the digital well-being of two cases of LA-supported educational technologies by using the data collection identified in earlier stages of the research. The main contributions related to the research objectives are shown in Figure 7.

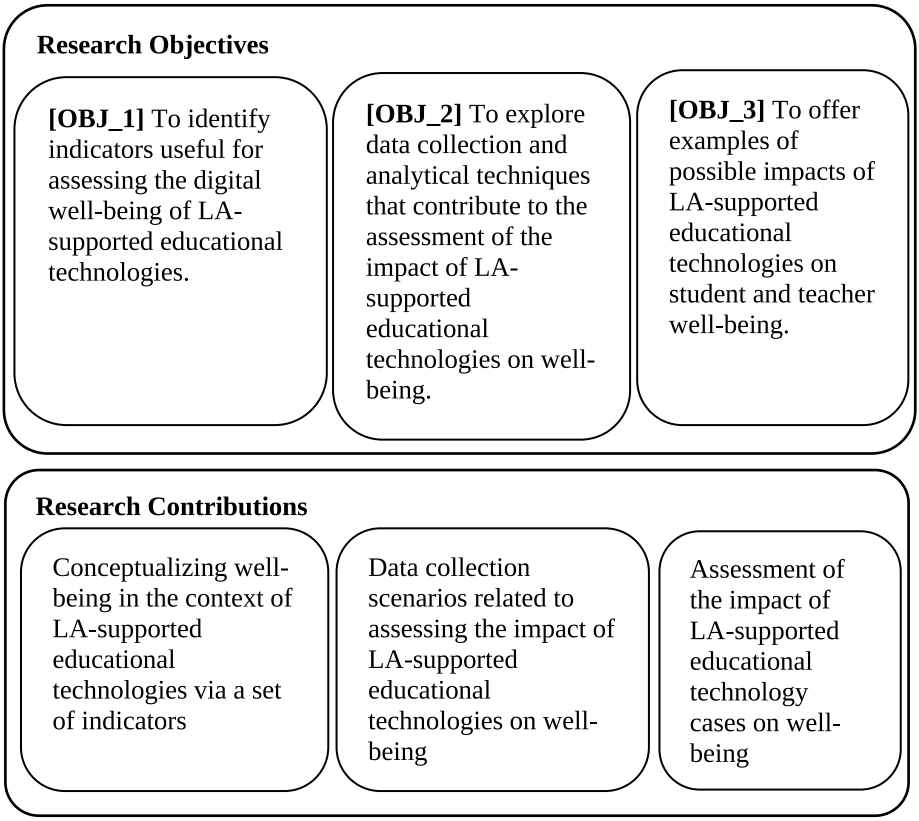

Figure 6. Main contributions associated with research objectives

- **Conceptualizing well-being in the context of LA-supported educational technologies via a set of indicators**

The first group of contributions is related to the identification of well-being indicators that can underline the well-being concept in TEL and LA research. Previous research indicated that despite the significant attention towards conceptualizing and evaluating well-being in policy and academia, well-being remains a narrowly defined concept in education and TEL research (Soutter, O'Steen & Gilmore, 2014; Osman & Ismail, 2019, Burr, et al., 2020). As a result, the efforts to efficiently plan for and monitor well-being in educational settings has been limited (Konu & Rimpel, 2002; Fraillon, 2004; Ereaut & Whiting, 2008). The diverse characteristics of TEL's stakeholders (e.g., students and teachers; children and adults, etc.) makes it challenging to agree upon a well-being conceptualization in TEL.

To pave the way towards a well-being concept in TEL that is holistic and yet applicable to existing LA-supported educational technology scenarios, we proposed applying the conceptual phase of IEEE P7010 standard within a diverse range of LA cases. The outcome of this activity contributes a total of 70 TEL-related well-being indicators across twelve domains selected by 22 LA researchers. The user engagement at the conceptual level of investigation in this research was limited to the cases of ILDE and PyramidApp, were samples of their users (i.e., teachers and students) asserted the findings obtained from the tools' developers regarding the impact on well-being.

According to the researchers participated in the IEEE P7010 internal analysis activity, reading about a wide spectrum of well-being areas and indicators supported their awareness of the several components of well-being and their capacity to tackle them in the future cycles of design. However, due to the nature of the IEEE P7010 standard, which encompasses a broad spectrum of well-being indicators that may be applicable to a variety of data-driven technologies, many of these indicators appeared to be very distant from TEL context during the analysis and indicator selection processes.

To broaden this conceptual investigation beyond the IEEE P7010 indicators and the LA examples under consideration while remaining focused on TEL research, a systematic literature review (SLR) on well-being and TEL was undertaken, covering the major TEL publication from 2013 to 2022. The findings of this SLR can help to further develop concepts based on TEL design methods and data gathering techniques (e.g., LA, Human-Cantered Design), thereby advancing TEL from a well-being standpoint. The contributions related to the first research objective are summarized in Figure 7.

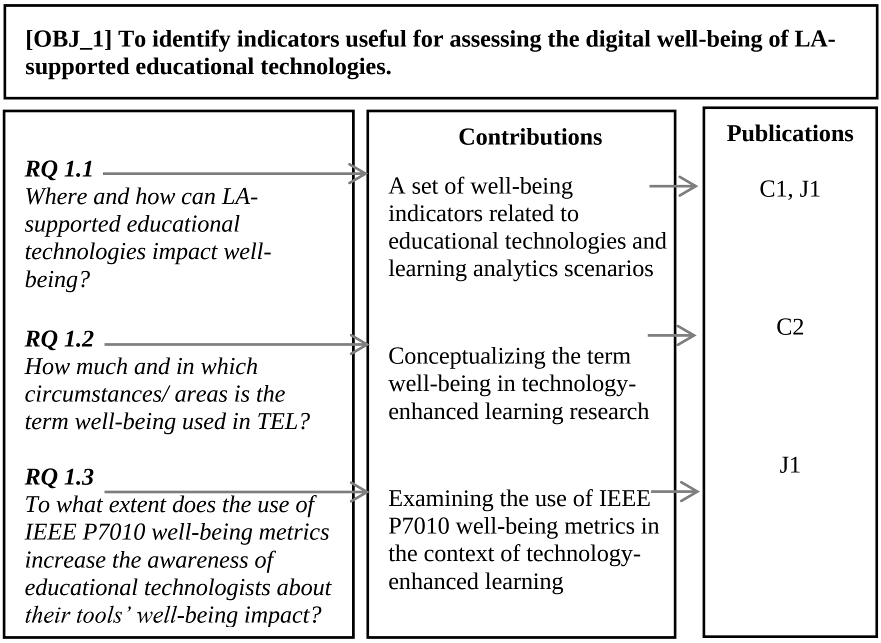

Figure 7 Contributions related to the first group of research questions

- **Data collection scenarios enabling the assessment of the impact of LA-supported educational technologies on well-being aspects**

The second group of contributions is related to the data collection techniques that can help quantify and understand the digital well-being of LA-supported educational technologies. Due to the wide range of tools and indicators discussed in the VSD conceptual phase of this research, it was found difficult to explore how to measure them all. Thus, exploring data collection methods for quantifying digital well-being in TEL contexts was limited to positive feelings and negative feelings, competence, autonomy relatedness. These indicators were selected due to their relevance to most of the cases included in the previous stage, i.e., conceptual investigation.

In the two cases of ANALYZE and TAP measuring positive feelings through LA was initially explored through a codesign workshop conducted within the Spanish Learning Analytics Summer Institute 2021 LASI21. Data sources, analytics, and key resources for measuring positive feelings were initially underlined; and the challenges to achieve the proposed solution were discussed.

In the case of PyramidApp, three scenarios for collecting data from samples of users were conducted. In the first scenario, a questionnaire derived from the METUX (Motivation, Engagement, and Thriving in User Experience) model (Peters, Calvo & Ryan, 2018) was used to explore how well a PyramidApp's interface satisfy students' psychological needs for competence, autonomy, and relatedness; and to test the instrument's validity in a CSCL context.

The second scenario aimed at exploring teacher-perceived stressful moments when orchestrating PyramidApp's activities in different learning settings (i.e., online, and face-to-face). A mixed-method survey was developed and used to understand the triggers of teacher-perceived stressful moments and the orchestration actions related to these moments during collaborative learning sessions facilitated by PyramidApp. The contributions related to the second research objective are summarized in Figure 8.

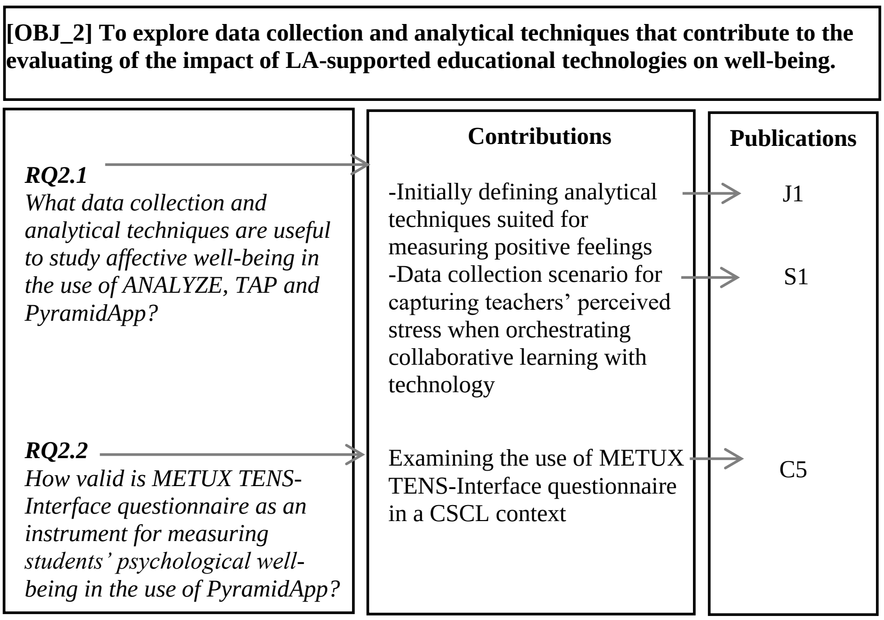

Figure 8 Contributions related to the second group of research questions

- **Assessment of the impact of LA-supported educational technology cases on well-being**

The third group of contributions is associated with the results obtained from the VSD investigations conducted throughout this research. The well-being indicators selected in the conceptual phase provide initial insights on where and how LA-supported educational technologies can impact well-being.

The users' and stakeholders' engagement in the cases of ILDE and PyramidApp provide further understanding of the well-being impact of these tools from the perception of students and teachers.

The findings obtained from the data collection scenarios for studying PyramidApp's impact on students' psychological well-being and teacher's stress provide more focused assessment for specific well-being aspects in a CSCL context. The contributions related to the third research objective are summarized in Figure 9.

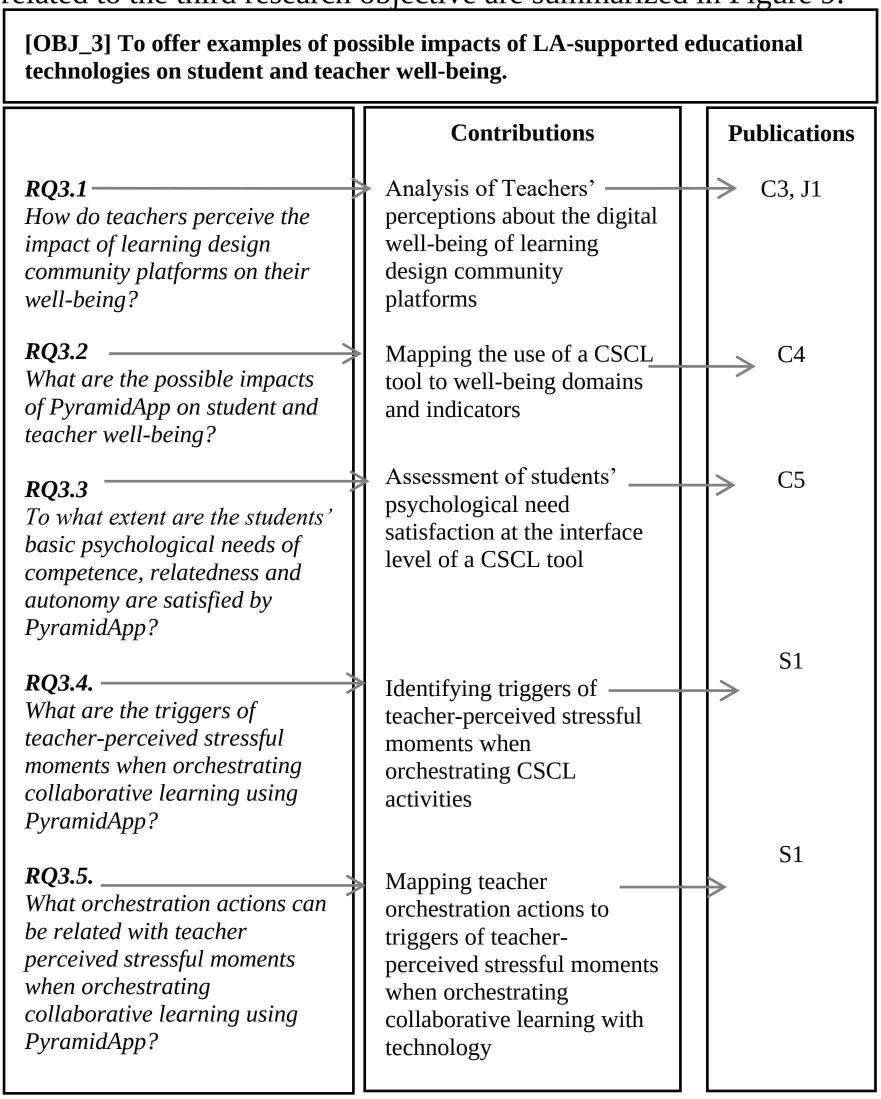

Figure 9 Set of contributions related to the third group of research questions

1.5.2. Publications

This dissertation is a compendium of the research articles listed in Table 3, which were published, submitted, or in the process of publication at the time of submission of the dissertation.

Table 3. List of publication included in the dissertation ordered by date of release

Publication*	Paper	Role
C1	**Hakami, E**., & Hernández-Leo, D.: 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. In LAK21: 11th International Learning Analytics and Knowledge Conference (LAK21), pp. 269–279. ACM, New York, NY, USA (2021). https://doi.org/10.1145/3448139.3448165	Leading author
C4	**Hakami, E**., Hernández-Leo, D., Amarasinghe, I.: Understanding the well-being impact of a computer-supported collaborative learning tool: the case of PyramidApp. In: De Laet, T., Klemke, R., Alario-Hoyos, C., Hilliger, I., Ortega-Arranz, A. (eds.) EC-TEL 2021. Lecture Notes in Computer Science, vol 12884, pp. 373–378. Springer, Cham (2021). doi.org/10.1007/978-3-030-86436-1_38	Leading author
C3	**Hakami, E.**, Hernández-Leo, D.: Teachers' views about the impact of Learning Design Community platforms on Well-being. In: Balderas A, Mendes AJ, Dodero JM, editors. 2021 International Symposium on Computers in Education (SIIE); 2021 Sep 23-24; Málaga, Spain. New York: IEEE (2021). 10.1109/SIIE53363.2021.9583651	Leading author
J1	**Hakami, E**., El Aadmi, K., Hernández-Leo, D., Santos, P., Álvarez, A., Caeiro-Rodríguez, M., Cobos, R., Ángel Conde, M., Dimitriadis, Y., Hernández-García, Á., Martínez-Monés, A., Muñoz-Merino, P. J., Sancho, T., and Vázquez-Ingelmo, A.: Towards Caring for Digital Well-being with the Support of Learning Analytics. IE Comunicaciones: Revista Iberoamericana de Informática Educativa. 34(4), pp. 13-29. (2021).	Leading author

C5	**Hakami, E.,** El Aadmi-Laamech, K., Hakami, L., Santos, P., Hernández-Leo, D., Amarasinghe, I.: Students' Basic Psychological Needs Satisfaction at the Interface Level of a Computer-Supported Collaborative Learning Tool. In: Wong, LH., Hayashi, Y., Collazos, C.A., Alvarez, C., Zurita, G., Baloian, N. (eds) Collaboration Technologies and Social Computing. CollabTech 2022. Lecture Notes in Computer Science, vol 13632, pp. 218–230. Springer, Cham (2022). https://doi.org/10.1007/978-3-031-20218-6_15	Leading author
C2	El Aadmi, K., **Hakami, E**., Santos, P; and Hernández-Leo, D.: The term well-being in Technology Enhanced Learning: A systematic literature review. In: 2022 International Symposium on Computers in Education (SIIE), IEEE (In press)	Co-author (conceptualization, one third of data collection and analysis and writing)
S1	**Hakami, E**., Hakami, L., Amarasinghe, I., Hernández-Leo, D.: Triggers of teacher-perceived stressful moments when orchestrating collaborative learning with technology. Submitted to the International Conference on Computer-Supported Collaborative Learning (CSCL 2023)	Leading author

**J: journal article; C: Conference paper; W: Workshop paper; BC: Book chapter; S: submitted (or about to be submitted) manuscript; D: Dataset*

In addition to the articles listed above, three articles and a dataset were associated with the work developed in this thesis (Table 4).

Table 4 List of publications related indirectly to the thesis

Publication*	**Paper**	**Role**
W1	**Hakami, E**., & Hernandez-Leo, D.: How are learning analytics considering the societal values of fairness, accountability, transparency and human well-being? A literature review. In LASI-SPAIN 2020: Learning Analytics Summer Institute (Spain 2020: Learning Analytics. Time for Adoption?), 15–16 June 2020, Valladolid, Spain, pp. 121–141. CEUR, Aachen, Germany (2020). http://ceur-ws.org/Vol-2671/paper12.pdf	Leading author

C6	Hakami, L., Amarasinghe, I., **Hakami, E.**, Hernández-Leo, D.: Exploring Teacher's Orchestration Actions in Online and In-Class Computer-Supported Collaborative Learning. In: Hilliger, I., Muñoz-Merino, P.J., De Laet, T., Ortega-Arranz, A., Farrell, T. (eds) Educating for a New Future: Making Sense of Technology-Enhanced Learning Adoption. EC-TEL 2022. Lecture Notes in Computer Science, vol 13450, pp. 521-527. Springer, Cham (2022). https://doi.org/10.1007/978-3-031-16290-9_45	Co-author (conceptualiza tion, writing)
BC1	Hernández-Leo, D., Amarasinghe, I., Beardsley, M., **Hakami, E.**, Ruiz García, A., Santos, P.: Responsible Educational Technology Research: From Open Science and Open Data to Ethics and Trustworthy Learning Analytics. In Raffaghelli, J., Sangrá, A., Data Cultures in Higher Education, Springer book series on Higher Education Dynamics. (In press)	Co-author (writing a section)
D1	**Hakami, E** & Hernandez-Leo, D.: Internal analysis for assessing the wellbeing impact of LA-supported learning technologies [Data set]. Zenodo (2021). https://doi.org/10.5281/zenodo.5810444	Leading author (Used in J1)

**J: journal article; C: Conference paper; W: Workshop paper; BC: Book chapter; S: submitted (or about to be submitted) manuscript; D: Dataset*

1.5.3. Projects

The research work carried out during this dissertation contributed to certain objectives of the following research projects:

- H2O Learn: Hybrid and Human-Oriented Learning: Trustworthy and Human-Centered Learning Analytics for Hybrid Education, PIs: Davinia Hernández-Leo, Patricia Santos, PID2020-112584RB-C33, 01/09/2021-31/08/2024.
- SNOLA, Spanish Thematic Network of Learning Analytics / Red Temática Española de Analítica de Aprendizaje, RED2018-102725-T, PI: Davinia Hernández-Leo, 10/2019-9/2021.
- SmartLET, Learning analytics to enhance the design and orchestration in scalable, IoT-enriched, and ubiquitous

Smart Learning Environments AEI TIN2017-85179-C3-3-R PI: Davinia Hernández-Leo, 01/2018-12/2020.

1.6. Conclusions

The overall aim of this thesis is to study the potential of LA-supported educational technologies to impact student and teacher well-being. Through three research objectives and a series of specific research questions, this work explored well-being indicators and data collection scenarios that could support the operationalization of the well-being impact assessment of LA-supported educational technologies.

VSD methodology supported by well-being metrics driven from IEEE P7010 standard were employed to achieve the dissertation goal, leading to certain contributions. The conclusions are diverse and will be presented in the order of the research objectives posed.

[OBJ_1] To identify indicators useful for assessing the digital well-being of LA-supported educational technologies.

The concept of well-being can be broken down into more manageable chunks, each of which can be better characterized by its own indicators. A total of 70 well-being indicators were selected by 22 LA researchers during two cycles of the first phase of the IEEE P7010 standard. Despite the differences (i.e., goals, users, etc.) between 16 cases of LA-supported educational technologies included in the conceptual phase of this research, most of them were found associated with the well-being domains of positive and negative feelings, psychological well-being in the term of capability, community in the sense of belonging, and education in the sense of satisfaction with educational systems. To a lesser extent, LA-supported educational technologies were found impactful on the domains of life satisfaction, work (due to its link with teachers), and mental and physical health. Few other impacts were identified on the well-being domains of culture, economy (e.g., standard of living), environment, human settlement (e.g., ICT skills) and government (e.g., sense of democracy).

This outcome is well aligned with the findings obtained from the literature on TEL and well-being, where the use of the term well-being in a TEL context interrelates in four main relevant domains (selected based on their frequent appearance in TEL research):

affect, community, psychology, and education. However, the affective domain was found especially relevant (appeared in ~76% of the analysed literature). This finding may provide a key for an argument stating that affect is a viable threshold for well-being. Some findings in (Costa & McCrae, 1980; Watson & Clark, 1984; Skinner, Furrer, Marchand, & Kindermann, 2008; IEEE Standards Committee, 2020; Cockerham, Lin, Ndolo & Schwartz, 2021) lend credence to the argument that one's emotional state is a fundamental measure of well-being.

Regarding the use of IEEE P7010 internal analysis process in LA contexts, the participants (i.e., LA researchers) found the well-being definitions and indicators provided by this standard rich and informative. They reported that the activity has increased the awareness of the potential well-being impact of their tools and, to a lesser extent, their capacity to address them in the design lifecycle.

[OBJ_2] To explore data collection and analytical techniques that contribute to the evaluating of the impact of LA-supported educational technologies on well-being.

Current or future us of LA in TEL can be optimized not only to understand and enhance performance (e.g., by monitoring students' progress), but also to capture and analyse important data that can be used determine where these technologies promote or diminish aspects of well-being for all the linked stakeholders. To further explore this potential within the indicator of positive feelings, a codesign workshop was held with ten LA researchers. Suggested data sources for measuring positive feelings in two cases of LA-supported learning technologies included users' subjective feedback, logs, physiological data (e.g., brain signals), video transcripts, and other sources. Natural Language Processing (NLP), process mining, pattern analysis and prediction techniques were some of the data collection analytical techniques suggested by the participants as enablers for measuring positive feelings when using TEL. Several barriers towards measuring well-being in TEL contexts were also identified. One of those is the lack of meaningful data. For example, using hardware sensors with students and teachers requires large amounts of data needed to be collected and analysed, which is challenging and can be intrusive for many subjects.

In the case of PyramidApp, we applied METUX TENS-Interface (Peters, Calvo & Ryan, 2018), a subjective questionnaire driven from Self-determination theory (Deci & Ryan, 1985; Ryan, 1995; Ryan & Deci, 2000; Ryan & Deci, 2008; Ryan & Deci, 2017), to explore students' perceptions on the extent to which their basic psychological needs of competence, autonomy and relatedness are satisfied when dealing with the interface of PyramidApp. The three sub-questionnaires of METUX TENS-Interface were analysed to assess their validity in a CSCL scenario. Cronbach's alpha values of 0.85 and 0.80, respectively, indicated that both the competence and relatedness subscales had strong internal consistency. The autonomy subscale, however, did not meet the minimum acceptable value of Cronbach's alpha, which was determined to be = 0.67 (Peters, Calvo & Ryan, 2018) and had a problematic internal consistency of = 0.63.

On the teacher side of using PyramidApp, the triggers of teacher-perceived stressful moments when orchestrating PyramidApp's activities in different learning settings (i.e., online, and face-to-face settings) were discovered. Different PyramidApp activities were designed. A Mixed-method survey was used to understand the triggers of teacher-perceived stressful moments and the orchestration actions related to these moments.

[OBJ_3] To offer examples of possible impacts of LA-supported educational technologies on student and teacher well-being.

The scope of well-being impact of LA-supported educational technologies is dependent on the context, goals, and type of stakeholders in the tool under objective. The conceptual investigation in this research provided initial insights on such a scope for several cases. Well-being indicators that interrelate to many of these cases can be considered a starting point towards understanding the overall scope of well-being impact in TEL and LA contexts. Possible impacts of several LA tools were initially identified within the full spectrum of well-being. Particularly, the affective well-being (e.g., stress), psychological well-being, social well-being in the sense of belonging and relatedness, and satisfaction with educational systems are among the most impacted well-being areas in TEL research. Work well-being was also found a relevant area of impact for the teacher users of TEL.

To consult users' perceptions on the case of ILDE, 68 instructors was surveyed as intended users. The teachers' views accord well with the systems' developers' assumptions of planned and unforeseen positive consequences of ILDE on teacher well-being. However, they don't match the negative impact assumptions.

More user engagement in the initial analysis of LA's well-being impact assessment was achieved through the use of PyramidApp, a CSCL case. Students and teachers who used PyramidApp concurred that the time constraints in PyramidApp learning activities might induce negative emotions such as stress and anxiety, but they also noted that this degree of stress could motivate students to develop ideas rapidly and be engaged in the learning process.

The findings shed light on how the PyramidApp's interface support the student's basis psychological needs of autonomy, relatedness, and competence, indicating that relatedness and completeness are more perceived by the students than autonomy when dealing with PyramidApp's interface. However, some students may also not perceive the competence and relatedness features, holding neutral positions toward a number of items on the METUX TENS-Interface competence and relatedness subscales. The findings therefore suggest the need for design interventions to improve the interface's usability and the components that promote engagement and a sense of belonging.

In the cases of PyramidApp teacher users, the findings indicated that the overall teacher-perceived stress level is higher in in-class sessions (M= 5.96, SD= 1.97) compared to online sessions (M= 3.3, SD= 1.73) in a ten-point scale completed in 36 occasions by five teachers. Through a qualitative analysis for 30 answers to an open-end survey item asking the participants to identify triggers of perceived stressful moments if any exist, issues related to technological difficulties, actions by students and time limits were found to be the main triggers of teacher-perceived stressful moments in the use of PyramidApp. About half of the discovered stressful moments were triggered by technological difficulties, while the dashboard intervention was the most related orchestration action to these moments.

1.7. Limitations

1.7.1. Theoretical limitations

The concept of well-being in this research is underlined by subjective and objective well-being indicators derived from IEEE P7010 standard (IEEE, 2020), and a systematic literature review on well-being and TEL that covers articles published in the top 20 TEL journals (as reported by Google Scholar) during the last ten years (2013-2022).

1.7.2. Methodological limitations

The VSD approach followed in this dissertation is limited to the conceptual phase for most cases. The user engagement is limited to two cases (i.e., ILDE and PyramidApp), and the scenarios for collecting well-being data was limited to one case that is PyramidApp, within specific aspects of well-being. In addition, the technical investigation in this research is limited to only identifying how existing cases of LA-supported educational technologies can possibly impact well-being, with no further technical interventions involved.

1.7.3. Data collection limitations

Measuring well-being is a developing area of research, with several perspectives of how it can be conducted, and which aspects of well-being are more crucial to be measured and enhanced. This also applies to assessing digital well-being, resulting in the difficulty of collecting data on all well-being aspects related to the use of a certain technology. Moreover, the process of measuring digital well-being could itself lead to lower levels of well-being, hence other codes and guidelines of data collection need to be carefully followed and considered in such processes. For example, using sensors to collect physiological data (e.g., heart rate, skin conductance) to study participants' stress required further permissions and standards that were not able to be met by the time of submitting this work. For the reasons above and more, the data collection scenarios where in most cases limited to subjective data provided by the sample of users after they consent to participate.

1.7.4. Covid19-related limitations

Due to the COVID-19 crisis starting in 2020, several workshops and data collection scenarios that were planned to be postponed, and a few were cancelled. These issues delayed the data gathering process and limited the number of cases and well-being aspects to be investigated.

1.8. Future Work

This section summarizes future research lines derived from the contributions and limitations of this thesis, which are listed as follows:

- **Identifying well-being indicators suited for educational technologies beyond the IEEE P7010 well-being metrics.** The main source of the well-being indicators explored in this thesis is the set of well-being indicators provided the IEEE P7010 recommended practice for assessing the well-being impacts of A/IS. The use of this source in LA contexts is justified in section 1.4.2; however, it remains a starting point towards a more holistic and agreed upon conceptualization of well-being in TEL research. Even though the systematic literature on well-being and TEL included in this thesis provides further insights on theoretically grounded conceptions of well-being, further in-depth research to tackle these concepts and their contexts is needed. The context and type of users of each technology play a major role in identifying the well-being indicators associated with it. Since the well-being indicators identified in this study are mainly driven by the use context of 16 cases of LA-supported educational technologies, they are not generalizable for other cases that do not share a common context and user characterization with the tools studied in this thesis. For example, when the users of a given tool in this research is specified as pre-service teachers, the selected indicators may not be applied to the case of younger K-12 student users. In the latter case, an analysis that takes in account the users' characteristics in needed, and well-being indicators for adolescents and children must be considered, such as The Child and Adolescent Thriving Index 1.0 (Anderson, et al, 2022). Further research and more cases studies are required to ensure the inclusion of well-being indicators that are relevant to TEL research, yet not included in this thesis.

- **Validating the well-being data collection instruments used for *ILDE* and PyramidApp.** Teachers' perceptions about the impact of ILDE on their well-being were collected through a 37-item Likert scale that we developed based on subjective and objective well-being instruments being used to measure nations' well-being (i.e., a level of validity). However, the survey items we formulated from these indicators requires further validation. Additionally, there is a need for scenarios and methods to collect data about specific aspects of ILDE users' well-being. In the case of PyramidApp, further validation of the use of METUX questionnaires in the tool's context is required through more data collection and reliability tests. In addition, the use of METUX needs to be validated in CSCL contexts beyond PyramidApp.

- **Collecting well-being empirical data for *PyramidApp* beyond stress and basic psychological needs**. The data collected from PyramidApp's users in this research is limited to the well-being domains of psychology, community and affect, represented by the well-being indicators of competence, autonomy, and relatedness (in the student cases) and stress (in the teacher cases). More well-being indicators that were identified in earlier stages of assessing the digital well-being of PyramidApp (e.g., learning improvement, satisfaction with relationships) need to be empirically investigated. To do so, data collection and analytical techniques to tackle these aspects need further exploration. Additional well-being indicators that associate with the CSCL field beyond the use of PyramidApp need to be identified and empirically studied as well.

- **Following empirical findings to perform technical interventions to *ILDE+* and *PyramidApp*.** As mentioned in the sections of methodology and limitations, the VSD technical investigation in this research is limited to studying how an existing technical solution supports or undermines well-being. Other types of VSD technical investigations are more focused on designing and redesigning technical solutions to support the underlined values in earlier phases. Such investigations are needed to consider the empirical data obtained from the users of ILDE and PyramidApp in the design of these tools. For example, modifying PyramidApp's interface to allow more students' autonomy can be one direction to tackle the lack of autonomy felt by students when using PyramidApp.

- **Performing VSD iterations for *ILDE+* and *PyramidApp*.** The samples of users who have participated in this study were all either instructors, undergraduate or graduate students. VSD iterations are needed where other types of the tools' targeted audience, such as K-12 students, are considered. To evaluate any future technical intervention driven by the findings of this cycle of VSD, further cycles are required to evaluate the solution presented.

- **Developing and implementing a well-being dashboard to support PyramidApp's developers in monitoring the tool to help safeguard well-being.** Despite the difficulties of collecting real-time well-being data from the users of PyramidApp, the endeavour to create a well-being dashboard that demonstrates relevant information about users' well-being can be reasonable. Such a dashboard is suggested by the IEEE P7010 recommended practice without providing specifications on how data should be collected, due to the contextual differences between the technologies covered by this guideline's scope. Data collection plans for each case are dependent on its context and what data are available. In the case of PyramidApp, the availability of log data and the possibility of collecting subjective data from users on regular basis can be one of the approaches to a developer-facing well-being dashboard, such for monitoring and improving the tool to help safeguard well-being.

1.9. Structure of the dissertation

This dissertation is presented as a compilation of the articles published or submitted for review at the time of depositing the dissertation. The following chapters are organized to include different articles as presented in Table 5. To integrate our research work, and to provide a sense of how each of the work presented in each chapter fits within the objectives stated, each chapter first provides a short introduction explaining how each article is related to the objectives of the dissertation.

Table 5 Overview of chapters and appendices

Chapter	**Title**	**Publication(s)***
Chapter 2	Well-being indicators for technology enhanced learning research	C1, C2, J1
Chapter 3	Teachers' views about the impact of Learning Design Community platforms on Well-being	C3
Chapter 4	Understanding the Well-Being Impact of a Computer-Supported Collaborative Learning Tool: The Case of PyramidApp	C4, C5, S1
Appendix A	How are learning analytics considering the societal values of fairness, accountability, ´ transparency and human well-being? A literature review	W1
Appendix B	Exploring Teacher's Orchestration Actions in Online and In-Class Computer-Supported Collaborative Learning	C6
Appendix C	Responsible Educational Technology Research: From Open Science and Open Data to Ethics and Trustworthy Learning Analytics	BC1
Appendix D	Internal analysis for assessing the well-being impact of LA-supported learning technologies	D1

Chapter 2 includes three sections related the first objective of this thesis, aiming at conceptualizing the term well-being in the context of LA-supported educational technologies. The chapter reports two cycles of applying the initial phase of the IEEE P7010 well-being impact assessment process to 16 LA cases, and a review of the literature. The chapter includes elements from the second and third objectives as well.

Chapter 3 includes one section reporting a study about the views of 68 teachers about the possible well-being impacts of learning design community platforms on their well-being.

The fourth chapter is composed of four sections focused on evaluating the well-being impact of a CSCL tool.

After the chapters, two articles and some related information (i.e., a data collection instrument) are included as appendices that are complementary to the work being presented in the chapters of the dissertation.

CHAPTER 2- WELL-BEING INDICATORS FOR TECHNOLOGY ENHANCED LEARNING RESEARCH

This chapter tackles the first objective of this thesis, which is aimed at conceptualizing well-being in TEL research and investigating well-being indicators that can be associated with cases of LA-supported educational technologies. The chapter consists of three sections: two conference papers and an invited journal article. Section 2.1 presents the findings of the application of the initial phase of IEEE P7010 recommended practice to a set of LA-supported educational technology cases. The aim of this section is to initially identify well-being indicators related to the TEL field from the perspective of LA researchers and tools' developers. Section 2.2 presents the findings of a systematic literature review aiming at conceptualizing well-being in TEL research. Section 2.3 is an invited journal article that includes three studies that tackles the first and parts of the second and third objectives. First, more researchers participated in the self-assessment process guided by the initial phase of the IEEE P7010 recommended practice. The usefulness this activity in increasing educational technologists' awareness of their products' impact on well-being was explored as well. Second, A sample of one the studied tools' users responded to a survey reflecting on the well-being indicators selected by the tool's creators. Third, a codesign workshop was conducted with LA researchers to explore how positive feelings can be tackled in to two LA cases.

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

The content of this section is published in the proceedings of the 11th International Learning Analytics and Knowledge Conference.

Hakami, E., & Hernández-Leo, D.: 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. In LAK21: 11th International Learning Analytics and Knowledge Conference (LAK21), pp. 269–279. ACM, New York, NY, USA (2021)

Research objectives

[OBJ_1] To identify indicators useful for assessing the digital well-being of LA-supported educational technologies.

[OBJ_2] To explore data collection and analytical techniques that contribute to the assessment of the impact of LA-supported educational technologies on well-being.

[OBJ_3] To offer examples of possible impacts of LA-supported educational technologies on student and teacher well-being.

RQ1.1 *Where and how car LA-supported educational technologies impact well-being?*

RQ1.2 *How much and in which circumstances/areas is the term well-being usec in TEL research?*

RQ1.3 *To what extent does the use of IEEE P7010 well-being metrics increase the awareness of educational technologists about their tools' well-being impact?*

RQ2.1 What data collection and analytical techniques are useful to study affective well-being in the use of ANALYZE, TAP and PyramidApp?

RQ2.2 How valid is METUX TENSInterface questionnaire as an instrument for measuring students' psychological wellbeing in the use of PyramidApp??

RQ3.1 *How do teachers perceive the impact of learning design community platforms on their well-being?*

RQ3.2 *What are the possible impacts of PyramidApp on student and teacher well-being?*

RQ3.3 *To what extent are the students' basic psychological needs of competence, relatedness and autonomy are satisfied by PyramidApp?*

RQ3.4 *To what extent does teachers' orchestration load differ in online sessions when compared to in-class sessions of CSCL activity orchestration?*

RQ3.5. *What are the triggers of teacher-perceived stressful moments when orchestrating collaborative learning using PyramidApp?*

RQ3.6. *What orchestration actions can be related with teacher perceived stressful moments when orchestrating collaborative learning using PyramidApp?*

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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ABSTRACT

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-centered computing** → Human computer interaction (HCI); HCI theory, concepts and models.

KEYWORDS

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 [4–6], and extending to societal values such as transparency, trust, fairness, accountability and social well-being [7–10]. 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.

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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-centered 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-fulfillment 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 [20–24]. 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).

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

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

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

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

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.

4.11 Human 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.

4.12 Work

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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2.2. The term well-being in Technology Enhanced Learning: A systematic literature review

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Research Objectives

[OBJ_1] To identify indicators useful for assessing the digital well-being of LA-supported educational technologies.

[OBJ_2] To explore data collection and analytical techniques that contribute to the assessment of the impact of LA-supported educational technologies on well-being.

[OBJ_3] To offer examples of possible impacts of LA-supported educational technologies on student and teacher well-being.

RQ1.1 *Where and how can LA-supported educational technologies impact well-being?*

RQ1.2 *How much and in which circumstances/areas is the term well-being used in TEL research?*

RQ1.3 *To what extent does the use of IEEE P7010 well-being metrics increase the awareness of educational technologists about their tools' well-being impact?*

RQ2.1 *What data collection and analytical techniques are useful to study affective well-being in the use of ANALYZE, TAP and PyramidApp?*

RQ2.2 *How valid is METUX TENS-Interface questionnaire as an instrument for measuring students' psychological well-being in the use of PyramidApp?*

RQ3.1 *How do teachers perceive the impact of ILDE on their well-being?*

RQ3.2 *What are the possible impacts of PyramidApp on learner and teacher well-being?*

RQ3.3 *To what extent are the students' basic psychological needs of competence, relatedness and autonomy are satisfied by PyramidApp's interface?*

RQ3.4 *What are the triggers of teacher-perceived stressful moments when orchestrating collaborative learning using PyramidApp?*

RQ3.5 *What orchestration actions can be related with teacher-perceived stressful moments when orchestrating collaborative learning using PyramidApp?*

The term well-being in Technology Enhanced Learning: A systematic literature review

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***Abstract*—Well-being as a concept has a wide spectrum, easily gaining an interdisciplinary quality more often than not. Its concurrent use in education is more prominent now, gaining relevance due to the discussions surrounding the ethical guidelines for the design of digital technologies and Artificial Intelligence (AI). This paper presents a systematic literature review aiming to explore the gray area that is the use of the word "well-being". The objective is to look further into the uses of the word, its formulated expressions, conceptualizations and areas of impact that are specifically focused and linked to Technology-Enhanced Learning (TEL). We find that the word "well-being" comes in various shapes and forms, sometimes accompanied by supporting expressions (e.g. emotional well-being, mental well-being) and other times used alone to address the state of wellness of a person. The results provided in this paper focus on the specific dimensions of well-being impact in TEL and are mainly classified by the identified contexts of use.**

Keywords—Technology-Enhanced Learning, Teacher Well-being, Student Well-being, Learning technologies

I. Introduction

A. Well-being: A brief theoretical scope

According to Osman and Ismail [42], a clear and consensual definition of what constitutes the term "well-being" is yet to be determined. The first entry in the dictionary of Cambridge defines well-being as "the state of feeling happy and healthy". In academia, it goes quite deeper than that; some studies interpret well-being in terms of (high) positive affect and (low) negative affect [12, 10], feeling good and functioning well [24], being satisfied with life [12, 1] as well as experiencing positive relationships, having a sense of purpose and developing one's potential [24]. Other studies take a more holistic approach and theorize about the different components that comprise the concept of well-being. For example, PERMA [51] defines well-being as built onto five components: positive emotion, engagement, positive relations, meaning and accomplishment. Or definitions aligned with the Self Determination Theory (SDT) [48] reckon that well-being derives from the fulfillment of three basic psychological needs: autonomy, competence and relatedness.

Bringing the concept of well-being closer to our context of research (i.e. TEL), we find that well-being is gaining traction in the ethical discussions surrounding the design of Artificial Intelligence (AI), digital technologies and the like, brought by the High-Level Expert Group on Artificial Intelligence (HLEG-AI) [22]. The HLEG-AI defines 7 basic requirements that build up the backbone of their proposed ethical guidelines: 1. Human oversight, 2. Technical robustness and safety, 3. Privacy and data governance, 4. Transparency, 5. Diversity, non-discrimination and fairness, 6. Societal and environmental well-being and 7. Accountability. On the same note, the Institute of Electrical and Electronics Engineers (IEEE) also delves into ethical aspects of such caliber through their IEEE Global Initiative on Ethics of Autonomous and Intelligent Systems A/IS, stating that the aim of ethical guidelines is that human well-being is to be prioritized in the design of digital technologies [25], assuring "a positive impact of A/IS on human well-being, while minimizing the risk of unintended negative outcomes" [25]. And as a follow up response, a set of guidelines aimed to assess the impact of autonomous and intelligent systems on human well-being was later released [26]: *IEEE Recommended Practice for assessing the Impact of Autonomous and Intelligent Systems on Human Well-Being*. Furthermore, this IEEE body of work comes with a well-being definition (contextualized in the purposes of Ethically Aligned Design); "well-being refers to an evaluation of the general quality of life of an individual and the state of external circumstances" and "the conception of well-being encompasses the full spectrum of personal, social, and environmental factors that enhance human life and on which human life depend" [26].

On a scoping view, [19] summarize the 12 domains of well-being impact proposed by the IEEE [26]: satisfaction with life, affect (feelings), psychological well-being, community, culture, education, economy, environment, government, health (physical and mental), human settlement, and work. Plus, a total of 134 well-being indicators classified under the 12 domains [26].

Furthermore, the concept of "digital well-being" seems to be weaving its way through into the well-being theoretical framework centered around the use of digital technologies: [4] refer to "digital well-being" as "the impact of digital technologies on what it means to live a life that is *good for* a human being". Nonetheless, its use as a concept remains to be widely adopted (at least in academic grounds) since authors seem to prefer using the more generic word (i.e. well-being) to also refer to the impact digital technologies have on overall characteristics of well-being.

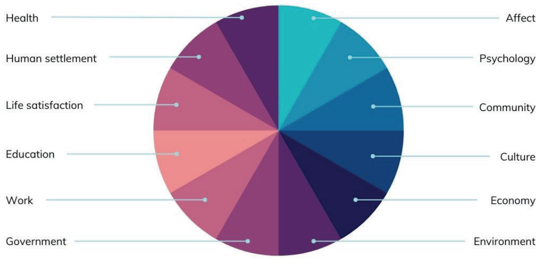

Fig. 1. The twelve well-being domains [26]

Due to the interdisciplinarity of the word "well-being", we believe that different understandings, expressions and conceptualizations can be formulated depending on the context of use (in this case TEL-centered). In this work, we aim to deepen our understanding on the given use and frequency of the word "well-being" and its variants in a specifically educational technology-driven setting, and if the specific uses (and their frequency) hint on possible implications related to the twelve well-being domains of impact. For that matter, we conducted this systematic literature review (SLR). The SLR is organized in the following manner: 2. Methodology (detailed with the different steps and guidelines), 3. Results (overall results of the coding) and 4. Discussion (contributions, conclusions and implications of the obtained results).

II. Methodology

The eight steps to conduct a systematic literature review of Okoli and Schabram [40] were followed as a guide due to their clarity and set of comprehensive steps: 1) Purpose and goal of the systematic review; 2) Protocol and training: setting the research guidelines; 3) Searching for the literature; 4) Practical screening: screening for inclusion; 5) Quality appraisal: screening for exclusion; 6) Data extraction; 7) Synthesis of studies; 8) Writing the review. We start by setting the purpose and goal of this study through one main research question (**RQ**): *How much and in which circumstances/areas is the term well-being used in TEL?*

The RQ will help us formulate a quantitative research on how frequently is the word well-being used in TEL and in which areas of impact, with both the explicit and implicit meaning of the word well-being.

A. Research guidelines

To search for the literature, the keyword string that has been validated by all the authors is the following: (*wellbeing OR well-being*) AND (*student* OR teacher**). To cover the TEL aspect of the RQ, the obtained sample through the keywords string has been filtered by the top 20 journals in TEL, a list reported by Google Scholar in the area of Computer Science (also in Education) and subarea of Educational Technologies. We also chose this list as it is the only ranking with the EdTech as an explicit category, plus it is widely accepted by the research community. A more detailed description on the inclusion and exclusion criteria can be seen in (Table 1).

The keyword string covers the main topic of interest "well-being" (and its other commonly used variant "wellbeing"), which is combined with two of the most relevant stakeholders within the TEL grounds: students and teachers, both as a means to limit the search and to focus it specifically on educational stakeholders' well-being. On the other hand, the reason TEL itself is not used in the keyword string is because of scarcity of results. This brings us to the second inclusion criteria (filtering by the top 20 TEL journals as reported by Google Scholar), which helps us locate relevant publications in the TEL field without explicitly using TEL in the keyword string. As for the research database we agreed on, Scopus is chosen since it covers a significant wide range of Computer Science, Education and interdisciplinary top scientific publications, including those broadly regarded with highest international recognition and covering the 20 TEL journals ranked by Google Scholar as well. The two final criteria (1. Abstract screening and 2. all publications are clearly linked to the RQ) are formulated in order to achieve a higher level of publications' relevancy, current impact and overall quality.

TABLE I. SELECTION CRITERIA

Criteria	**Description**
Keyword string	(wellbeing OR well-being) AND (student* OR teacher*)
Inclusion and exclusion criteria	1.All publications must be indexed within Scopus citation database 2.Only publications published within the last 10 years (2013-2022) are considered 3.All publications must be published within the top 20 journals in TEL according to Google Scholar metrics 4.Publications with no abstract are excluded
Quality screening	1.All resulting publications are to undergo an abstract screening before in-depth review 2.All publications are relevant or clearly linked to the RQ

As a final note addressing the reviewing process itself, we used co-creation and co-editing real time tools (i.e. Google Docs, Google Sheets) aside from scheduling regular meetings with all the involved authors to report progress and keep an ongoing working flow.

B. Coding

Once all the inclusion and exclusion criteria have been applied, the number of relevant publications is n=57, which in turn are conducted through an abstract screening process (quality criteria). The abstract screening focused on three major aspects: 1) there needs to be an educational technology involved in the study, 2) at least one of the two main stakeholders (teachers and/or students) needs to be involved and 3) At least one expression or mention of well-being should be present. Therefore, the final sample that has been worked with in the SLR is that of n=46.

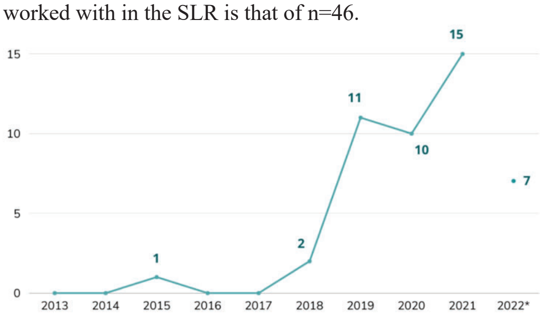

Fig. 2. Temporal distribution of the final sample of relevant publications. *(Note that for the year 2022, only publications of January-February were considered due to time logistics).

The resulting data is coded in two levels: 1. Coding by well-being domains: As a first level of coding, we aim to classify the different articles by their well-being domain(s) after the in-depth revision. This will help us contextualize the article, give an initial answer to the RQ and therefore facilitate the subsequent level of coding. 2. Coding by well-being expressions; since well-being is used to refer to or address various aspects of wellness, the usage of a number of well-being expressions is expected. Therefore, a second level of coding by well-being expressions will be critical to grasp a better understanding of the usage of the word itself within the respective well-being domain(s) and its specific context of use.

III. Results

First coding set: The first set of coding classified the final literature sample (n=46) into the twelve different domains of well-being previously discussed. As seen in Figure 3, a total of 10 domains out of the 12 domains were identified. It is worth noting that articles are not limited to just one domain, but rather classified in the total number of domains we observed most relevant to the context of the article.

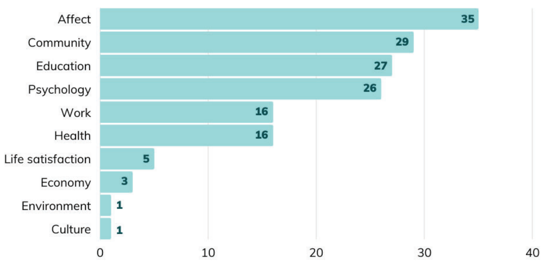

Fig. 3. Domain distribution of the resulting literature.

Second coding set: An important aspect of this coding set is that we classify the identified expressions in two subsets; 1. Explicit well-being expressions: expressions that use the well-being word explicitly to refer to a more generic understanding of well-being or to a specific well-being aspect. 2. Implicit well-being expressions: expressions that do not use the word well-being explicitly to refer to a well-being related aspect. These expressions are identified through their connection with the twelve domains of well-being – e.g. well-being indicators [26]. It is important to note that the number of expressions that we classified from each article refers to that of the total number of unique expressions only (i.e. repeated expressions are not counted) (Table 3).

On the other hand, whilst coding we came across two coding exceptions: 1. some implicit expressions (e.g. competence, motivation) do get repeated in different domains (i.e. psychology, education) and 2. explicit but generic notions of well-being that could not be classified under one definite well-being domain: integral well-being [41], human well-being [49], greater overall well-being [49], ill-being [27].

IV. Discussion

A. *Relevant well-being domains in TEL*

First of all, we find that the use of the word well-being in a TEL context interrelates in four main relevant domains (selected due to their frequency level; Affect, Community, Psychology and Education) and one conditional domain (selected due to its natural link with teachers; Work). As seen in Table 2, Affect, Community, Psychology and Education are the most frequently used domains.

A sixth domain also seems to be relevant in the quantitative data: Health. We would like to open a parentheses to address this specific domain and why it has not been considered with the other relevant domains: almost half (n=7) of the total articles (n=16) classified under the Health domain are COVID-19 centered. It is important to note that we consider the pandemic as an extraordinary event that led educational institutions to take urgent measures, transitioning teaching and learning abruptly from a face to face setting to an online one [35]. Which in turn seems to have affected the learning process of the students negatively [8, 31]. Teachers also reported a general dissatisfaction with the lack of a planned approach and having to integrate technology into their teaching practice by their own means [57].

TABLE II. Coding: First coding set – Domain classification and explicit expressions

Domain	Explicit expressions
Affect *(n=35)*	*(n=4)*: **emotional well-being** [60, 41, 63, 43, 29, 36, 64, 39, 47]; **positive well-being** [7, 65], **social emotional well-being** [63]; **emotional social and cognitive well-being** [3].
Community *(n=29)*	*(n=5)*: **social well-being** [7, 2, 14, 36, 15, 39, 29, 49]; **social emotional well-being** [63]; **emotional social and cognitive well-being** [3]; **psychosocial well-being** [49]; **collective well-being** [47].
Education *(n=27)*	*(n=3)*: **well-being related to learning** [21]; **school well-being** [14]; **academic well-being** [52].
Psychology *(n=26)*	*(n=4)*: **psychological well-being** [30, 60, 63, 59, 53, 15, 45, 44, 61, 49, 27, 65]; **subjective well-being** [21, 60, 7, 16]; **personal well-being** [63]; **psychosocial well-being** [49], **psychosomatic well-being** [33].
Work *(n=16)*	*(n=1)*: **job well-being** [50]
Health *(n=16)*	*(n=5)*: **mental well-being** [54, 7, 2, 18, 14, 45, 39, 13]; **mental wellness** [2]; **physical well-being** [36, 15, 39]; **spiritual well-being** [39]; **psychosomatic well-being** [33]
Life satisfaction *(n=5)*	*(n=1)*: **subjective well-being** [60]
Economy *(n=3)*	*(n=0)*
Environment *(n=1)*	*(n=0)*
Culture *(n=1)*	*(n=0)*

TABLE III. CODING: SECOND CODING SET – IMPLICIT EXPRESSIONS

Domain	Implicit expressions
Affect *(n=35)*	*(n= 22)*: **anxiety** [6, 53, 56, 34, 47]; **stress** [50, 59, 38, 45, 44, 5]; **positive emotions** [21, 60, 3, 43, 36, 66]; **negative emotions** [21, 3, 43]; **academic stress** [46]; **positive affect** [7, 27]; **negative affect** [7, 27]; **affective competencies** [3]; **positive affective state** [3]; **socio-emotional impacts** [58]; **emotional labor** [59, 45, 44]; **emotional social support** [59]; **negative emotional development** [23]; **emotional stress** [43]; **emotional exhaustion** [43, 17]; **emotional support** [43]; **emotional responses** [14]; **depression** [17]; **affective expression** [49]; **gratitude** [60, 16]; **thankfulness** [16]; **emotional engagemen**t [16].
Community *(n=29)*	*(n=23)*: **sense of relatedness** [6]; **community support** [6, 38, 28]; **institutional belonging** [50]; **social connections** [60]; **social experience of a learning community** [46]; **online connectedness** [46]; **social relationships** [7, 36, 66, 16]; **social interaction** [7]; **social connectedness** [7]; **collaborative** [28]; **relationship-building** [63]; **interpersonal relationships** [63]; **coexistence** [3, 47]; **socio-emotional impacts** [58]; **emotional social support** [59]; **relationship difficulties** [38]; **social appreciation** [17]; **abuse** (cyberbullying) [37]; **peer-related stress** [5]; **social presence** [49]; **teacher support** [11]; **social inclusion** [20]; **social agreement** [20].
Education *(n=27)*	*(n=17)*: **learning support** [6]; **academic development** [46]; **academic success** [60]; **academic experiences** [46]; **academic performance** [46, 5, 20]; **academic stress** [46, 38]; **teaching-learning progression** [41]; **energy (learning motivation)** [41]; **learning needs** [23]; **learning performance** [49, 65]; **school climate** [14]; **happiness in learning** [11]; **teacher learning** [11]; **learning achievement** [11]; **academic achievement** [27, 16]; **positive learning experience** [56]; **teacher education** [56].
Psychology *(n=26)*	*(n=20)*: **self-efficacy** [6, 59, 43, 18, 56, 34, 65]; **self-acceptance** [30]; **autonomy** [6]; **competence** [6, 27, 56, 34]; **relatedness** [6]; **sense of capability** [18]; **self-esteem** [7, 38, 15, 16]; **self-confidence** [7, 59, 38, 15]; **engagement** [7, 66, 16]; **motivation** [7, 3, 27, 20]; **self-motivation** [63, 3]; **cognitive competencies** [3]; **behavior change** [38]; **lack of autonomy** [45]; **trust** [45]; **personal accomplishment** [44, 66]; **depersonalisation** [44]; **depression** [17, 5]; **psychological need satisfaction** [27]; **feelings of amotivation** [20].
Work *(n=16)*	*(n=13)*: **competence** [6]; **professional development** [54, 43]; **institutional commitment** [50]; **job stress** [50]; **passion burnout (motivation)** [41]; **job satisfaction** [50, 59, 44, 17]; **teacher burnout** [43]; **secure and healthy work environment** [28]; **lack of flexible working opportunities** [45]; **work-life balance** [45]; **academic staff workload** [52]; **teacher learning** [11]; **employability** [34].
Health *(n=16)*	*(n=5)*: **mental health** [54, 16]; **health** [3, 58, 23, 38, 36]; **teaching physical demands** [58]; **health problems** [23]; **general health** [29].
Life satisfaction *(n=5)*	*(n=2)*: **satisfaction with life** [21, 60, 7, 36]; **goals** [7].
Economy *(n=3)*	*(n=4)*: **low income negative effects** [54]; **financial difficulties** [38]; (financially) **underprivileged students** [11]; **socio-economic status of students** [11].
Environment *(n=1)*	*(n=1)*: **sustainable environment** [28].
Culture *(n=1)*	*(n=1)*: **art education to "improve people's spiritual realm"** [32].

However, as many changes as the pandemic brought, we must make a clear difference between the usage of digital technologies in planned approaches (online learning with sufficient time of preparation) and situations of forced implementation of digital technologies due to an urgent need (such as war, natural disasters and pandemics) [35]. We approach the COVID-19 pandemic as the latter. Therefore the pandemic-oriented reports should be addressed cautiously since they might bring biased data focused mainly on the pandemic well-being notions, rather than the well-being notions related to digital technologies in a state of perceived normalcy, since that is the goal of this SLR. Nonetheless, it is also true that the pandemic raised the importance of taking into consideration the topic of well-being in education, therefore monitoring the well-being state and how it is addressed during and after the pandemic could also bring some interesting insights in further research on well-being in TEL.

B. Affect: A predominant domain in TEL well-being scope

We observe that the different well-being domains remain mainly subjected to the context of use of the well-being expressions (e.g. economy, culture and environment as seen in Table 3). For instance, the results we got indicate that some domains are more relevant than others in terms of frequency at least. Therefore, it is only natural that the level of relevance of the different domains shifts depending on the context in which the well-being expressions are used. Following this logic and applying it to the results of domain appearance frequency (Table 2), we fin that the affective domain is especially relevant (appearing in ~76% of the analyzed literature). These results could potentially hint to an argument: affect is not only a domain, but a potential threshold of well-being. This argument is supported by some insights present in [9], [62], [55], [26], [7], arguing that affect is indeed a core indicator of well-being. Further supporting evidence falls on some of the results we got in Table 3: implicit affective expressions are ones of the most quoted across the different articles considered for this SLR (i.e. positive emotions [21], [60], [3], [43], [36], [66]; stress [50], [59], [38], [45], [44], [5]; anxiety [6], [53], [56], [34], [47]).

Another domain worth mentioning due to its interrelating nature with other domains is that of Psychology: we can find the different implicit expressions (e.g. competence; relatedness) to be easily related to other domains (i.e. work: worthwhile teaching; community: sense of support).

C. Conclusions and implications

The notion of well-being is subdivided into smaller domains, each of which is more precisely defined by its own set of indicators. To address the impact of educational technologies on well-being, there is a need for framing the use of the well-being concept in TEL in such a way that researchers and technologists can take it into account while designing and evaluating educational technologies. As a step in this direction, this work aims to gain a better knowledge of which of the well-being components are more relevant to the field of TEL. A systematic review of the literature on well-being and TEL was undertaken, encompassing the major TEL publication from 2013 to 2022. According to the findings, the well-being domains of affect, psychology, community, education, and work can be regarded as key well-being elements in the TEL context due to their continuous use and frequency across the different analyzed literature. Moreover, the implicit expressions used to describe these domains provide us with specific indicators for what implications the well-being notion has in TEL. For example, the expressions of stress, anxiety, and positive emotions were cited as frequent indicators for the affective well-being domain, and expressions like autonomy, capability, motivation and self-acceptance were likewise frequently used under the psychological well-being domain. This paves the way for additional in-depth research into learner well-being, as well as teacher and staff well-being, while taking into account the contextual environment for each stakeholder. Furthermore, having into account these indicators could further develop the notions built around TEL design methodologies and data collection processes (e.g. Human-Centered Design, Learning Analytics), improving the educational technologies from a well-being perspective in at least the proposed domains of impact within the obtained results of this SLR.

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2.3. Towards Caring for Digital Well-being with the Support of Learning Analytics.

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Research Objectives

[OBJ_1] To identify indicators useful for assessing the digital well-being of LA-supported educational technologies.

[OBJ_2] To explore data collection and analytical techniques that contribute to the assessment of the impact of LA-supported educational technologies on well-being.

[OBJ_3] To offer examples of possible impacts of LA-supported educational technologies on student and teacher well-being.

RQ1.1 *Where and how can LA-supported educational technologies impact well-being?*

RQ1.2 *How much and in which circumstances/areas is the term well-being used in TEL research?*

RQ1.3 *To what extent does the use of IEEE P7010 well-being metrics increase the awareness of educational technologists about their tools' well-being impact?*

RQ2.1 *What data collection and analytical techniques are useful to study affective well-being in the use of ANALYZE, TAP and PyramidApp?*

RQ2.2 *How valid is METUX TENS-Interface questionnaire as an instrument for measuring students' psychological well-being in the use of PyramidApp?*

RQ3.1 *How do teachers perceive the impact of ILDE on their well-being?*

RQ3.2 *What are the possible impacts of PyramidApp on learner and teacher well-being?*

RQ3.3 *To what extent are the students' basic psychological needs of competence, relatedness and autonomy are satisfied by PyramidApp's interface?*

RQ3.4 *What are the triggers of teacher-perceived stressful moments when orchestrating collaborative learning using PyramidApp?*

RQ3.5 *What orchestration actions can be related with teacher-perceived stressful moments when orchestrating collaborative learning using PyramidApp?*

Towards Caring for Digital Wellbeing with the Support of Learning Analytics

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Resumen: Este artículo describe tres estudios que analizan el impacto de las tecnologías del aprendizaje en el bienestar, así como el papel que las Analíticas del Aprendizaje pueden desempeñar en la medición y mejora de dicho impacto. Para empezar, diez investigadores españoles utilizaron las métricas de bienestar IEEE P7010 para analizar el impacto de sus productos en el bienestar. También respondieron a encuestas previas y posteriores para evaluar el impacto del ejercicio en su capacidad para desbloquear el potencial de sus herramientas para promover el bienestar. Posteriormente, 68 maestros saudíes participaron en una sesión en línea y completaron una encuesta sobre una de las tecnologías bajo investigación. Finalmente, los investigadores participaron en un taller de co-diseño para proponer escenarios de Analíticas del Aprendizaje para cuantificar el impacto de ciertos aspectos del bienestar. A pesar de los diferentes contextos, objetivos y usuarios de las herramientas exploradas en este documento, se identificaron posibles impactos en todo el espectro del bienestar. Argumentamos que el uso de las Analíticas del Aprendizaje puede ayudar considerablemente a cuantificar la medición de los elementos de bienestar tanto dentro como fuera de los entornos de aprendizaje, hecho que permite que el impacto en el bienestar se revise y mejore constantemente.
Palabras clave: Bienestar, Analíticas del Aprendizaje, Diseño del Aprendizaje, Ética, Valores

Abstract: This article describes three studies that looked into the impact of learning technologies on wellbeing, as well as the role that Learning Analytics can play in measuring and enhancing such an impact. To begin, ten Spanish researchers used the IEEE P7010 wellbeing metrics to analyse their products' wellbeing impact. They also responded to pre- and post-surveys to assess the exercise's impact on their ability to unlock the potential of their tools to promote wellbeing. Then 68 Saudi teachers participated in an online session and completed a survey regarding one of the technologies under investigation. Finally, the researchers participated in a co-design workshop to propose learning analytics scenarios for quantifying the impact on certain aspects of wellbeing. Despite the different contexts, goals, and users of the tools explored in this paper, possible impacts across the full spectrum of wellbeing were identified. We argue that using

Learning Analytics can considerably help in quantifying the measurement of wellbeing elements both within and outside of learning settings, allowing the wellbeing impact to be constantly reviewed and enhanced.
Key words: Wellbeing, Learning Analytics, Learning Design, Ethics, Values

1. Introduction

The world of information is today mediated by digital technologies where the growing involvement of data analytics and Artificial Intelligence (AI) in everyday life is likely to present issues with lasting consequences. The individual and societal wellbeing is becoming intimately connected with the state of our information environment and the digital technologies that underpin our life experiences (Burr, Taddeo & Floridi, 2020). The global efforts toward evaluating and enhancing the impact of such technologies on wellbeing continue to establish guidelines and metrics for such systems to remain human-centric, serving humanity's values and ethical principles. These efforts include two recent reports by the Institute of Electrical and Electronics Engineers (IEEE) under the umbrella of the IEEE global initiative on Ethics of Autonomous and Intelligent Systems (A/IS), providing guidance to wellbeing researchers as well as those creating and using automated data analytics and AI solutions (Musikanski, 2020).These two productions of the A/IS initiative consist in a publication entitled “Ethically Aligned Design” (EAD) (IEEE, 2019), and a standard entitled “P7010–2020 Recommended Practice for Assessing the Impact of Autonomous and Intelligent Systems on Human Wellbeing” (IEEE, 2020). The IEEE aims at establishing wellbeing metrics to enable technologists to better consider how the products and services they create can enhance human wellbeing based on a wider spectrum of measures than growth and productivity alone (IEEE, 2020).

AI methods and algorithms are becoming more involved in how decisions are made in public and private life. The presence of this shift in the field of education is represented by the data collection and management of learners' data for the purpose of understanding and optimizing learning. Consequently, the collection and use of educational data pose a range of ethical issues, including the location and analysis of data; informed consent, privacy and de-identification of data; and the classification and management of data (Slade & Prinsloo, 2013; Kimmons, 2021; Beardsley, Santos, Hernández-Leo & Michos, 2019). Other ethical questions being tackled by researchers in the field of Learning Analytics (LA) raise thorny questions about how and what data are dealt with in educational environments and extend to societal topics like transparency, trust, fairness, accountability, and social wellbeing (Drachsler & Greller, 2016; Buckingham Shum, 2017; Gardner, Brooks & Baker, 2019; Chen & Zhu, 2019; Alwahaby, Cukurova Papamitsiou & Giannakos, 2021). However, there is a research gap in considering the potential of LA to impact the wellbeing of learners and teachers from a holistic perspective in ways that go beyond enhancing learning outcomes.

In this paper, we apply an assessment process consisting of three studies (Table 1) guided by the IEEE P7010 wellbeing metrics (IEEE, 2020) to a set of LA-supported educational technologies to answer the following questions:

RQ1: Where and how can LA-supported educational technologies impact on wellbeing?
RQ2: To what extent does the use of IEEE P7010 increase the awareness of educational technologists about their tools' wellbeing impact?
RQ3: How can Learning Analytics be extended to measure wellbeing elements?

	RQ	Activity	Participants
Study 1	1, 2	Pre survey, Internal analysis, Post survey	LA researchers n=10
Study 2	1	Online tutorial, Survey	Teachers n=68
Study 3	3	Co-design workshop	LA researchers n=10

Table 1: Research design of studies

First, ten Spanish LA researchers belonging to the Spanish Network of Learning Analytics (SNOLA) were engaged in an internal analysis process to initially identify where and how their tools may impact wellbeing. They did so by selecting wellbeing instruments already in use and have been proven to be an accurately measurement instrument (i.e., scientifically valid) to reflect the wellbeing impact of their tools. They also responded to pre and post questionnaires to evaluate how this activity could help them realise the potential of their tools to impact wellbeing. In the second study, 68 Saudi teachers attended an online tutorial session about one of the studied tools and reflected on the wellbeing indicators selected by the LA researcher who developed it. Finally, the LA researchers participated in a co-design workshop to identify data sources and analytical techniques that can help measure the impact on a given wellbeing aspect.

The rest of this paper starts with a brief review on the ethics of digital wellbeing and their implications in the field of LA. Then we explain the IEEE P7010 Recommended Practice for Wellbeing Impact Assessment and how it can be used to safeguard wellbeing in data-driven digital spaces. Afterwards we present the methods and findings of each study and conclude the paper by an overall discussion on the three studies and the promises and challenges of using LA to measure and enhance wellbeing.

2. Ethics of Digital Wellbeing

Since their first advent, digital technologies have been connected to ethical questions and concerns about their impact on people's lives and the wellbeing of individuals and communities. The expression "digital wellbeing" is used to refer to the impact of digital technologies on what it means to live a life that is good (Floridi, 2014). Wellbeing refers to what is directly or ultimately good for a person or population, and it is not limited to one or two dimensions, but rather encompasses the full spectrum of personal, social, and environmental factors that enhance human life and on which human life depends (IEEE, 2019).

To the extent that data analytics and AI techniques add to digital technologies in terms of capability and impact, they add a heavy burden of ethical concerns that are more crucial than ever before. The field of education was like many other sectors affected by the increasing use of digital technologies and thus by the technological pathways opened by the flow of data from such technologies. Big and small data techniques are being presented and used in the field of education in the form of Learning Analytics, which is defined as 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 (Long & Siemens, 2011). As the use of LA has increased, a variety of ethical considerations have covered critical data-related issues like privacy and protection and have extended to other important societal values. However, a significant research gap remains in considering the potential of LA to impact the wellbeing of learners and teachers from a holistic perspective in ways that go beyond the learning aspects. A recent review on the theme of digital wellbeing by Burr, Taddeo & Floridi, (2020) highlights major issues related to four key domains, including education, where digital technologies have increasing roles and impact. The review referred to articles that had discussed, for example, how digital technologies could support lifelong learning and openness to new opportunities (Pedaste & Leijen, 2018); how gamification-based learning could improve cognitive skills (Karime, Hafdh, Khaldi, Aljaam & El Saddik, 2012); and how smartphones could automatically detect moods and help with work-life balance and management through increased awareness of stress and emotional understanding (Baras, Soares, Paulo & Barros, 2016).

2.1. IEEE P7010 Recommended Practice for Wellbeing Impact Assessment (WIA)

As a methodology, WIA consists of five activities: 1) Internal, user, and stakeholder analysis, 2) wellbeing indicators dashboard creation, 3) data collection plan and data collection, 4) wellbeing data analysis and use of wellbeing indicators data, and 5) Iteration. The focus of this paper is related to the first and third activities, where subjective and objective data are collected from the creators and the users of LA-supported technologies to investigate how the digital wellbeing of these tools can be understood and measured.

The IEEE P7010 recommended practice provides 134 indicators drawn from wellbeing 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 a wide range of data-driven technologies on each of the following wellbeing domains: life satisfaction, affect (feelings), psychological wellbeing, community, culture, education, economy, environment, government, health (physical and mental), human settlement, and work.

3. Methodology

We applied three connected studies to answer the three research questions of this paper (Table 1). First, ten Spanish LA researchers who have been involved in the creation processes of ten LA-supported educational tools and services participated in an internal analysis process for the purpose of identifying useful indicators that can reflect the wellbeing impact of each system. This task was conducted with the aim of increasing the participants' awareness of wellbeing domains and indicators, and therefore their capacity to address and evaluate the wellbeing impact of their systems. The participants responded to a short prequestionnaire and reflected on the usefulness of this internal analysis activity through a post questionnaire. Second, 68 teachers participated in an online tutorial and provided data on how a specific LA-supported tool, such as a learning design community platform may impact their wellbeing as users. Third, a co-design workshop was conducted with the LA experts to find out how to quantify the measurement of wellbeing through LA.

4. STUDY 1: LA Researchers' Views about the Wellbeing Impact of LA-supported Tools

This study was conducted by applying the first activity of the IEEE P7010 standard, initial internal analysis, to the creators of ten LA-supported educational tools and services that were in different stages of the design lifecycle. The task was conducted with the aim of increasing the participants' awareness of wellbeing domains and indicators, and therefore their capacity to address and evaluate the wellbeing impacts of their systems. This activity was carried out 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 wellbeing? 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.

4.1. Pre survey

Before conducting the internal analysis process, the LA experts were asked to complete a short qualitative survey to investigate their awareness about their tools' wellbeing impact before applying the IEEE P7010 internal analysis activity. They were requested to answer the following question:

- *Indicate a tool using learning analytics that you have designed or co-designed. Have you observed any positive or negative impact of your tool on the users' wellbeing? If there are any, please explain.*
  (Hakami and Hernández-Leo, 2021a)

4.2. Internal Analysis

The IEEE P7010 internal analysis process is designed to be conducted by the tools' creators alone and should involve forecasting, hypothesising, projecting, utilising scenarios, and other means of internal analysis (IEEE, 2020). The participants conducted this activity to answer the first question of this study through an online-based session that we held to present the materials of this activity, followed by asynchronous individual analysis and post-activity survey. The WIA methodology provides a set of 134 indicators that measure 12 wellbeing domains (2-23 indicators per domain) within definitions of each domain and subdomain.

The activity was conducted in a manner where each participant was allowed to 1) identify the system's goals, users, and stakeholders, 2) read the definitions and indicators of each wellbeing domain and subdomain, 3) select indicators that reflect potential impacts of each tool on the wellbeing of its users, stakeholders, and the society; and 4) provide optional explanations and justifications about their indicator selections. This activity produced a group of indicators that initially identified the scope of wellbeing impact of the studied LA-supported educational technologies. Findings that are related to the eleventh tool in this study (Learning Design Community Platforms ILDE) are reproduced from (Hakami and Hernández-Leo, 2021b; Hakami and Hernández-Leo, 2021c).

4.3. Post Survey

After the participants completed the internal analysis activity, they were asked to fill a post Yes/No questionnaire to evaluate the usefulness of IEEE P7010 in increasing their awareness of their tools' wellbeing impact. They also were asked to provide further optional explanations on their answers. The questions were driven from the IEEE P7010 internal analysis checklist and were as follows:

- *Have possible impacts on wellbeing been identified?*
- *Were unintended and unexpected issues considered, such as potential biases and negative impacts, including how risks and negative impacts to human wellbeing can be mitigated?*
- *Has this activity increased your awareness of wellbeing domains and indicators that are relevant to your system?*
- *Has this activity increased your capacity to address and evaluate the impact of your system on wellbeing?*
  (Hakami and Hernández-Leo, 2021a).

4.4. Findings

The LA researchers' responses to the pre activity question are presented in (Table 2). The LA researchers' descriptions for their tools' goals and users are explained in (Table 3). The findings of the internal analysis process are represented in (Table 4), where the twelve wellbeing domains are listed within the indicators selected by the participants to reflect the wellbeing impact of each tool.

	Indicate a tool using learning analytics that you have designed or co-designed. have you observed any positive or negative impact of your tool on the users' wellbeing? If there are any, please explain.
1	Positive: Reduction of cognitive load, stress and time consumption among users (instructors). Awakening of curiosity from data exploration and discovery.
2	This tool is useful to intervene in real time. So it has a positive impact on academic staff and, finally, students.
3	Our tool hasn't been tested yet with end users
4	It reduces their anxiety and increases their sense of fairness while we are assessing their activities in the group. They feel happier with this way of evaluating their work in a group
5	Some students become more involved and interested about their progress.
6	Sometimes it may create stress to the teachers, and feelings of reduced agency. Comparisons with others may be either beneficial or not.
7	I observed positive impacts in the fact that the teacher could rely on the tool to be aware of situations that s/he was not able to control "manual". The teacher understood the output perfectly (it was very simple). The teacher was in control, because it was her responsibility to decide what to do with the information given by the tool. The tool facilitated an email address to contact the student in an efficient way, if the teacher decided to do so after the information given by the tool.
8	The negative aspects can be related to the fact that it was necessary to do some extra work in advance, in the definition of the "teacher's pedagogical intention" so that the system could work.
9	We have not really tested well-being for the tool in detail
10	Yes, the learner'' performance was improved.

Table 2: LA researchers' responses to the pre activity question

LA Tools	Description
Dashboard Generator (DB)	A meta-modeling based approach that allows the generation of tailored dashboards including LA dashboards. **Users:** Any. **Other stakeholders:** Any
AdESMuS	System oriented to support users in complex assessment scenarios through different modules of visualization. **Users:** Teachers and learners. **Other stakeholders:** Academic managers
Glimpse	It is a system that uses teachers' pedagogical intention to set up rules that are checked against data collected from several sources of data, including self-reported data, VLEs and external tools. **Users:** Teachers. **Other stakeholders:** Learners
Early Warning System (EWS)	It is a web-based tool that provides information about possible learners in danger taking into account the interactions with an assessment supporting tool. **Users:** Teachers and learners. **Other stakeholders:** Academic managers
MWDEx	A system that facilitates the instructor's observation and analysis of peer assessment activities by downloading and preparing data from Moodle Workshops and offering visualization and analysis capabilities. **Users:** Teachers. **Other stakeholders:** Learners
Teacher Action Planner (TAP)	The TAP is aimed at providing an actionable dashboard for teachers to manage design and orchestration (or even design) of science inquiry activities that are carried out with the WISE system. **Users:** Teachers. **Other stakeholders:** Researchers, academic managers and learners
ANALYSE	A web-based tool that provides different dashboards about students' progress and students' activities with exercises and videos in the Open edX platform. **Users:** Teachers and learners **Other stakeholders:** Academic managers
RAC	A web-based tool integrated in the Virtual Campus where teachers introduce evaluation activities marks and provide personalized feedback. Students access this application in order to see the academic results. **Users:** Teachers and learners. **Other stakeholders:** Academic managers
Teamwork assessment of Telegram Messages (TATM)	An LA tool that gathers and presents the indicators relevant for the evaluation of students' individual acquisition of teamwork competence taking into account CTMTC methodology. **Users:** Teachers. **Other stakeholders:** School community members
edX-LIMS	edX-LIMS (acronym of System for Learning Intervention and its Monitoring for edX MOOCs) is a web-based Learning Analytics System that provides an intervention strategy on the learners' learning and the monitoring of the mentioned strategy by the instructors. Users: Stakeholders:
Learning Design Community Platforms (ILDE)[1]	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 **Users:** Teachers. **Other stakeholders:** Learners, academic managers, school community members

Table 3: Descriptions of the tools included in this study

[1]*Data related to ILDE is reproduced from (Hakami and Hernández-Leo, 2021b; Hakami and Hernández-Leo, 2021c).*

Impacted areas (wellbeing domains)	Selected indicators	Impacting systems
satisfaction with life	Sense that on''s life is the best to worst possible life for them at the time.	ANALYSE, TATM, ILDE
	How satisfied are you with your life nowadays?	AdESMuS, Glimpse, TAP, ANALYSE, TATM, ILDE
	Satisfaction with life as a whole.	DB, Glimpse, TAP, ANALYSE, TATM, ILDE
Affect	Positive affects: feeling happy, calm, peaceful.	DB, AdESMuS, Glimpse, EWS, MWDEx, ANALYSE, TATM, ILDE, edX-LIMS
	Negative affects: feeling sad, depressed, stressed anxious.	DB, Glimpse, EWS, ANALYSE, ILDE
Psychological wellbeing	Feeling that the things one does are worthwhile.	DB, AdESMuS, Glimpse, EWS, MWDEx, TAP, ANALYSE, ILDE
	Sense one is capable and good at what they do.	DB, AdESMuS, Glimpse, EWS, MWDEx, TAP, ANALYSE, TATM, ILDE, edX-LIMS
	Sense that one leads a purposeful and meaningful life.	DB, TAP, ANALYSE, TATM, ILDE
Community	Sense of belonging to a community.	DB, AdESMuS, Glimpse, EWS, TATM, ILDE, edX-LIMS
	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.	Glimpse, TAP, ILDE
	Sense that most people can be trusted or that one needs to be very careful in dealing with people.	Glimpse, TAP, ILDE, edX-LIMS
	Satisfaction with relationships.	TATM
	Sense of discrimination in one's neighbourhood or community in one's neighbourhood.	Glimpse, TAP, TATM
	Approximate total hours a month one was active in voluntary organizations.	ILDE
Culture	Engagement with / participation in arts or cultural activity.	ILDE
Education	Satisfaction with educational systems or schools in area in which one lives.	DB, AdESMuS, EWS, MWDEx, TAP, ANALYSE, RAC, TATM, ILDE, edX-LIMS
	Access to opportunities to learn.	DB, ANALYSE, RAC, ILDE, edX-LIMS
	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.	EWS, RAC, ILDE, edX-LIMS
	Average years of schooling.	DB, EWS, TAP, RAC, TATM
Economy	Degree to which one is worried about losing their job or not finding a job.	DB, ANALYSE, ILDE, edX-LIMS
	Unemployment rate, by sex, age and persons with disabilities.	DB, TAP, ANALYSE, edX-LIMS
	Income inequality or rich-poor gap or Gini index.	TAP, ANALYSE
Environment	Satisfaction with efforts to preserve the environment.	ILDE
	How much (people) know about global warming or climate change.	ILDE
Government	Satisfaction with one's last experience of public services.	EWS, ANALYSE, IDLE, edX-LIMS
	Laws, policies, and practices guarantee equal treatment of various segments of the population.	DB, ANALYSE, edX-LIMS
	Sense there is equality of opportunity and the absence of economic exploitation.	ANALYSE, edX-LIMS
	Sense there is freedom of assembly, demonstration, and open	ILDE, edX-LIMS

	public discussion.	
	Sense there is respect for individual human rights nowadays in one's country.	Glimpse, ANALYSE, ILDE
	Print, broadcast, and / or internet-based media are not directly or indirectly censored.	edX-LIMS
	Attendance of peaceful demonstrations in the last year.	edX-LIMS
	Sense of confidence in government -national, local, civil service, judicial system, police, political parties. etc.	edX-LIMS
	Sense that government is free from pervasive corruption.	edX-LIMS
Health	Healthy life expectancy.	edX-LIMS
	Sense of having enough energy to get things done.	Glimpse, TAP, ANALYSE, ILDE, edX-LIMS
	Sense that one's state of health is good.	ANALYSE, edX-LIMS
	Number of persons who have seen a health professional during a year.	Glimpse, ANALYSE, edX-LIMS
Human settlements	Satisfaction with beauty or physical setting.	edX-LIMS
	Proportion of population living in households with access to basic services.	edX-LIMS
	Satisfaction with availability of good affordable housing	edX-LIMS
	Secure access to food	edX-LIMS
	Satisfaction with transportation system in the city or area one lives	edX-LIMS
	Proportion of youth and adults with information and communications Technology (ICT) skills, by type of skill.	Glimpse, MWDEx, TAP, ANALYSE, ILDE, edX-LIMS
	Proportion of population covered by a mobile network, by technology.	TAP, ANALYSE, TATM, ILDE, edX-LIMS
	Access to internet at home.	ANALYSE, ILDE, edX-LIMS
	Having a computer at home.	ANALYSE, TATM, ILDE, edX-LIMS
	Having a cellular phone.	ANALYSE, ILDE, edX-LIMS
Work	Satisfaction with job.	DB, AdESMuS, Glimpse, MWDEx, TAP, ANALYSE, ILDE, edX-LIMS
	Sense that current work life is interesting.	DB, Glimpse, TAP, ILDE, edX-LIMS
	Sense that one's supervisor has respect for and cares about one's welfare.	Glimpse, TAP, ILDE
	Sense that one gets support and help from co-workers.	TAP, ILDE, edX-LIMS
	Sense that the conditions of one's job allows one to be about as productive as one could be.	AdESMuS, MWDEx, TAP, ILDE, edX-LIMS
	Satisfaction with the balance between the time spent on the job and the time spent on other aspects of life.	DB, TAP, ILDE, edX-LIMS
	Satisfaction with opportunities for professional development and promotion in one's current primary job.	TAP, ANALYSE, ILDE, edX-LIMS
	Sense of independence one has in performing tasks at work.	Glimpse, MWDEx, TAP, ILDE, edX-LIMS
	Average hours of training per year per employee.	TAP, edX-LIMS
	Identifying and managing economic, environmental, and social impacts.	ANALYSE
	Satisfaction with salary and benefits in current primary job	edX-LIMS
	Percentage of employees receiving regular performance and career development reviews	edX-LIMS
	Operations with local community engagement, impact. assessments, and development programs.	ANALYSE
	Mechanisms for advice and concerns about ethics.	Glimpse, TAP, ANALYSE

Table 4: Indicators selected by LA researchers to reflect the wellbeing impact of their tools

Among the 134 indicators that had been presented to the participants, a total of 61 indicators were selected to reflect the impact of the studied tools on the twelve domains of wellbeing (Table 4). Seven out of ten LA researchers who participated in the IEEE P7010 internal analysis activity found the process useful in increasing their awareness of wellbeing domains and indicators that can be relevant to the use of their products. Six of the participants indicated that it helped them identify wellbeing impacts of their tools. Five participants indicated that it increased their capacity to address and evaluate the identified impact, and only four participants responded with yes to whether the activity allowed them to identify unintended and unexpected issues, such as potential biases and negative impacts, including how risks to human wellbeing can be mitigated (see Figure 1).

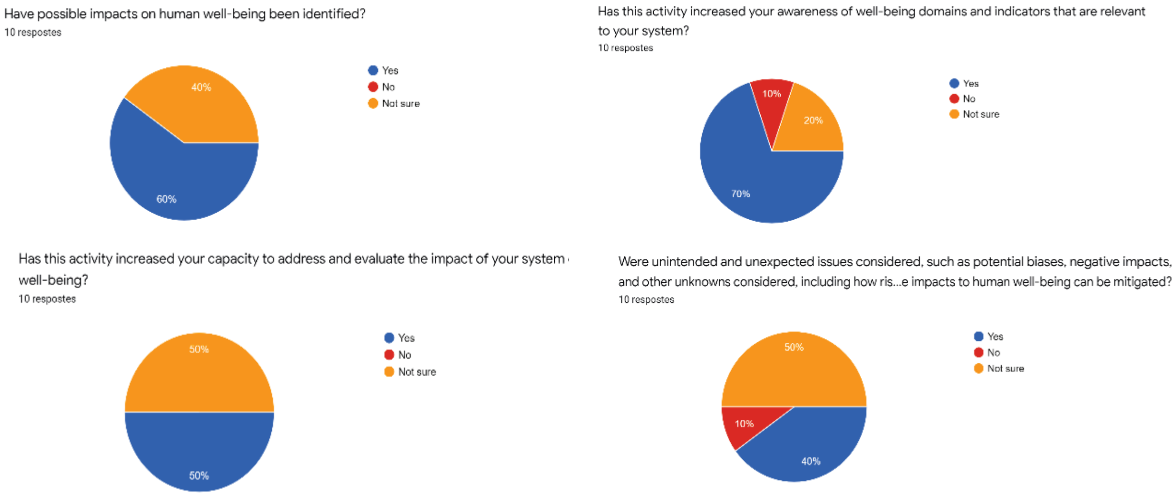

Figure 1: LA researchers' responses to the post activity survey

5. STUDY 2: Teachers' Views about the Impact of Learning Design Community platforms on Wellbeing: The case of ILDE

Learning design is defined as "the creative and deliberate act of devising new practices, plans of activity, resources and tools aimed at achieving particular educational aims in a given context" (Mor, Craft & Hernández-Leo, 2013). Learning design community platforms are web-based platforms with integrated lesson planning tools that support teachers in the creation, co-creation, and sharing of designs of learning activities.

This study aims at investigating the wellbeing impact of ILDE (Integrated Learning Design Environment), a learning design community platform, from the perspective of teachers as the intended users of such tools (Hernández-Leo et al., 2018). The invitation to participate in this study was spread among teachers of all levels in Saudi Arabia. We arranged a one-hour online session, where 78 teachers attended and were presented to a demo of the online learning design community ILDE, explaining all its uses and features. Although the tool we demonstrated was a prototype with usability challenges, the participants were able to reflect on it based on not only the extended details provided in the demo, but also on their experience with similar tools and services provided by their educational systems to support them in the novel virtual learning and teaching environments.

5.1. Data collection and analysis

Among the 78 who attended the session, 68 teachers (56 females and 12 males) confirmed the consent to participate in the study and completed a questionnaire of 37 Likert items where they were asked to agree or disagree with statements drawn from the wellbeing indicators selected in study 1 in this paper. About 37% of the participants (25 out of 68) were high school teachers, 35% were primary school teachers, 18% were middle school teachers, and only 7 of the participants (10%) were university instructors. About 66% of the participants have been teaching for more than 15 years, while 16% and 15% of them have been teaching for 11–- 15 years and 6–- 10 years, respectively. Only two of them (3%) have less than five years of teaching experience. The responses to the survey started to arrive 25 minutes after the end of the session and the last response received was about four days later. The video tutorial of the tool had been uploaded to be available for rewatching by the participants after the session ended.

The survey items include statements that tackle both positive and negative wellbeing impacts based on the indicators that were selected by ILDE creators and shown in Study 1 (Table 4). In the case of assuming both types of impact may occur in different ways and for independent reasons, we formulate two items from the same indicator. For example, from the psychological wellbeing indicator “Feeling that the things one does are worthwhile” we developed the Likert items: “The use of the tool can make me feel that the things I do are worthwhile” and “The use of the tool can make me feel that the things I do are worthless”. The format of each five-level item was as follows: 1. Strongly disagree, 2. Disagree, 3. Neither agree nor disagree, 4. Agree, 5. Strongly agree. (Hakami and Hernández-Leo, 2021c).

5.2. Findings

In (Table 5), the positive impact is the percentage of the average number of agreements with positive statements and disagreements with negative statements within a specific wellbeing domain, while the negative impact is represented by the percentage of the average number of disagreements with positive statements and agreements with negative ones.

Wellbeing domain	**Positive impact**	**Negative impact**
Life satisfaction	70.55%	13.63%
Affect	65.94%	15.85%
Psychological wellbeing	78.68%	11.4%
Community	59.05%	18.13%
Culture	72.1%	11.8%
Economy	70.55%	14%
Environment	63.2%	11.8%
Government	63.64%	10.61%
Health	71.35%	13.2%
Education	82.4%	10.3%
Human Settlement	83.8%	7.4%
Work	70%	14.42%

Table 5: Summary of teachers’ views about the impact ILDE on each wellbeing domain (n=68)

6. STUDY 3: Wellbeing and Learning Analytics Workshop: Co-designing LA to detect, quantify and measure wellbeing related aspects

To further understand how wellbeing measurement can be done through LA tools, a workshop with LA experts was carried out in the context of wellbeing in education at the Learning Analytics Summer Institute Spain (LASI Spain 2021), organized by SNOLA. The main activity of the workshop was the co-design of a LA tool from a wellbeing standpoint, a tool that could further dive into wellbeing detection and measurement features. The objective of the workshop resided in identifying which aspects of the resulting data could help in taking one more step towards quantifying the measurement of wellbeing aspects through Learning Analytics.

6.1. Co-Design workshop format

The content of the activity was designed following the data previously collected through the internal analysis process conducted in Study 1 with LA experts. As previously exposed, the questionnaire focused on the LA tools experts usually employ and the wellbeing indicators they found most relevant and impactful in their practice. The activity was mainly built on these two elements, and it consisted of five main segments which are introduced in more detail in the next paragraph. The workshop was conducted through a hybrid setting, using the collaborative Miro platform (visual collaboration platform) as the hosting space for the activity and adapting it to participation needs since there were both online and face to face participants. Furthermore, all the collected data from the participants during the activity were automatically stored in the online platform for its posterior consultation and analysis.

The segments of the activity were five, after a brief welcome and quick agenda review; (i) *Introduction to Wellbeing and LA tools*: The first segment presented the working materials of the activity, which were the Wellbeing indicators and the LA tools previously compiled through the initial questionnaire with experts; (ii) *Icebreaker*: Since the participating profiles were various, ranging from LA experts and practitioners to doctoral students, the ideal group setting was to have a balance in both expertise and profiles. The participants were asked to choose one or two options presented in the activity regarding their level of expertise and wellbeing area of interest. Once the participants chose their options, the workshop facilitator proceeded to create the groups and balance them in regards to expertise in the LA field and common interests of the participants; (iii) *Wellbeing indicator and LA tool*: Once the groups were formed, the next step was to discuss in group and to choose which LA tool and wellbeing indicator they wanted to work with during the co-design activity (all groups were presented with the same board of information on the Wellbeing indicators and the LA tools they can choose from); (iv) *Brainstorm and co-design the wellbeing-related LA tool*: The fourth and main segment of the collaborative workshop activity. The structure of this segment was inspired by some features of a co-designing format previously used in the design of LA tools (Prieto Alvarez, Martínez-Maldonado & Anderson, 2018) and the Learning Analytics Design Cards (LA-DECK), a card-based technique that can be used to support the co-designing process of LA tools (Prieto Alvarez, Martínez-Maldonado & Buckingham Shum, 2020). This worksho''s own co-designing activity format employs a total of 6 cards inspired by the LA-DECK for the participants to fill. These cards are the following:

- *Objective card*: Define the goal you want to achieve related to your wellbeing indicator.
- *Data source car*d: Define the source of the data that should be collected in relation to both your goal and wellbeing indicator.
- *Analytics car*d: Define the analytics or set of analytics you believe are most suited to analyse your selected wellbeing indicator.
- *Metrics car*d: Define the metrics you believe are most appropriate to measure your selected wellbeing indicator.
- *Resources car*d: Define any kind of key resources you think will be necessary to achieve your goal.
- *Free space car*d: Add any other relevant info you believe is necessary to achieve your goal.

Participants were invited to add their thoughts in a sticky note inside the online board, using one sticky note per thought or idea; (v) *Evaluate your results*: In the fifth and final segment of the activity, participants were told to evaluate their results based on the ideas they came up with and the group discussion they had during the process. In order to guide this segment, 4 questions were asked:

- What are the perks of your design?
- What are the downsides of your design?
- What was the most challenging part about the co-design of your ideal tool in relation to the wellbeing indicator you selected?

- How achievable do you think your tool is? (1-5 Likert scale, 1 being *Not achievable* and 5 being *Perfectly achievable*). Justify the score accordingly.

Once the five segments of the activity have been finished, the participants are redirected to a final space where they are thanked for their active participation and are encouraged to give any feedback regarding the activity planning plus their thoughts on using collaboration tools like Miro for the co-design process.

	Wellbeing indicator	**Tool**
Group 1	Positive feelings	ANALIZE
Group 2	Positive feelings	TAP

Table 6: Third study participation summary.

6.2. Findings

The total number of participants was 18 (face-to-face and online), with 10 face-to-face participants that volunteered to actively participate in the workshop activity. The profiles were mainly two (6 LA experts and 4 PhD students). Participants were split into 2 groups of 5. To balance out the groups, each one of the two groups had at least one LA expert familiar with one of the LA tools, serving as group mediator.

Once the introductory activities had been completed, the groups proceeded to complete the main workshop activity. A summary of the most relevant responses can be seen in Table 7.

	Group 1	**Group 2**
Objective card	Extend ANALIZE to measure positive feelings.	Our goal is to know how to change TAP in order to improve the teacher's positive feelings
Data source card	Direct student feedback when working on / completing an exercise “"how do you feel about this exercise”") Video cameras EGG signals, brain signals, pulse signals Learning experience Logs with exercises Logs with videos Eye tracking Text messages Task duration Video transcription	Use of the tool while the teacher creates a plan Teacher profile Student / class profile (i) Teacher planning, (ii) Teacher expectation, (iii) Student’s results
Analytics card	Natural language processing Analyzing timestamps Process mining Pattern sequence Prediction techniques Deep learning	Tool timestamps Current state of tasks Teacher’s performance
Metrics card	Task duration Positive text Sentiment Low pulse How close to the deadline was the task completed Facial expression Consecutive positive actions Performance Efficiency	Teachers current state vs. teacher state in a previous timestamp Learning Action before vs. learning action after
Resources card	A lot of hardware (video cameras, various sensors) Integration experts	Sentiment Analysis Indicator AI model We need four

	Software implementation of the new measures Someone to do video transcripts Time and money Data analysis experts Ethical experts Pedagogical experts	employees: two developers, one AI expert, one person with educational background
Free space card	Theory on how best to measure positive feelings Usability Stakeholders implication Evaluation Validation	Direct enhancement of teacher'' feelings through student'' feelings

Table 7: Co-design workshop results: *Brainstorm and co-design the wellbeing-related LA tool* (Study 3).

Finally, the last activity was conducted as a self-evaluation of the groups' obtained results during the ideation and co-design session (Table 8).

	Group 1	**Group 2**
Positive aspects	Using hardware sensors: - Strong measure - Lots of data to analyse Using NLP and direct student feedback: - Non-invasive - "Easy" to implement	Focus on positivity
Negative aspects	Using hardware sensors: - Intrusive - Difficult in a MOOC environment Using NLP and direct student feedback: - Not the most precise measure Implementation of an algorithm to analyse all the data	Lack of meaningful data
Challenges faced	Fighting with the MIRO platform Measuring wellbeing is hard	How do we find out the correlation between teacher/student actions and positive feelings?
Is it achievable? (1-5 scale)	Using hardware sensors: - Score: **1/5** - In principle feasible to implement but requires a lot of resources and would very likely be too cumbersome for practical use. In particular if we consider that ANALYZE is used in a MOOC-context, where using hardware sensors is unrealistic (except for maybe video footage that they would have to provide voluntarily). Using NLP and direct student feedback: - Score: **5/5** - This approach seems to be more feasible as it uses student feedback and no sensors are needed. However, it is not as precise.	Viable, but a big amount of work required. Score: **3/5**

Table 8: Co-design workshop results: *Evaluate your results* (Study 3)

7. Discussion

The aim of LA research and practice to understand and improve learning and the environment in which it occurs can be extended to support other various elements of human wellbeing. 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 and how these technologies impact the wellbeing of all related stakeholders. To further investigate how learning technologies could impact wellbeing considering the promising and concerning roles of LA, we used wellbeing metrics from the IEEE P7010 recommended practice to allow the digital wellbeing of selected LA-supported tools to be extensively tackled and assessed.

Despite the variety in the educational contexts, objectives, users, and stakeholders of the studied tools in this paper, possible impacts of all of them were identified on several areas within the full spectrum of wellbeing. A total of 61 Indicators (between 4 to 41 per tool) were selected by the LA experts from a list of 134 wellbeing indicators. The selections were made to reflect the potential wellbeing impact of each tool. Most of the selected indicators focused on the domains of satisfaction with one's life and job, positive and negative feelings, psychological wellbeing, community (i.e., sense of belonging), and education in both versions of formal education and lifelong learning. To a lesser extent, the domains of work and health were highlighted to be potentially impacted by several tools. Few other impacts were identified on the wellbeing domains of culture, economy (i.e., jobs), environment, human settlement (i.e., ICT) and government (i.e., sense of democracy).

The participants reported that reading about all these domains and indicators helped them become conscious about many aspects of wellbeing. However, while carrying out the analysis and the indicator selection process, many of those indicators had appeared to them as very far away from their tool context due to the nature of the IEEE P7010 standard that covers a wide spectrum of wellbeing indicators that might be relevant to a wide range of data-driven technologies. For example, the domain of human settlement included 19 indicators used to measure wellbeing on dimensions of housing, food, transportation, and ICT. Only the five indicators under the subdomain of ICT were found relevant to the participants' cases. Non-selected items also included 15 indicators that measure environmental wellbeing in dimensions of water, air, soil, and biodiversity; while the only two selected indicators in this domain were related to the satisfaction with the efforts to preserve the environment, and the knowledge about climate change.

The users' engagement in this investigation was limited to the case of ILDE learning design community platform that is mainly used by teachers. The views of 68 teachers that participated in this study about the impact of ILDE were well aligned with the hypotheses put by the system's creators regarding impacts on different dimensions of teacher wellbeing. However, they do not align with the hypotheses of potentially negative impacts, neither the ones suggested by the system's creators, nor the ones added by us to balance the survey. A possible reason for this could be the differences in the levels of criticism and awareness of harm between the system's creators (i.e., researchers), and the users (i.e., teachers). In the stage preceding this study, the researchers had attempted to adhere to the IEEE P7010 internal analysis regarding the rigor of their assessment of the well-being impacts, by assuming several scenarios of varying likelihood of occurrence, some of which are found unlikely by the users. For example, the researchers expressed that the negative feelings of anxiety and frustration could 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, while most of the teachers in this study do not report such possibilities.

As a means to obtain more specific results on what are the most relevant wellbeing aspects for educational stakeholders, in the third study we worked with a reduced list of 6 wellbeing indicators (satisfaction with life, positive feelings, negative feelings, sense of one's work worthiness, sense of capability, sense of leading a meaningful life and sense of belonging to a community) and 5 LA tools (Dashboard Generator, ANALYSE, AdESMuS, Glimpse and TAP), all previously compiled in the first study with LA experts. The criteria for selecting these tools consisted in (i)participants having sufficient knowledge of the tools and (ii) interest shown in the specific wellbeing indicators exposed above.

In this third study there were 2 groups that volunteered to actively participate. Each group worked with a different LA tool (TAP and ANALYSE) and the same wellbeing indicator (positive feelings). Since they had the freedom to choose these two factors and both coincidentally chose the same wellbeing indicator, it was a good opportunity to compile data and compare it from two different yet similar LA tools' perspectives.

We were able to obtain relevant data on what are the critical analytics and metrics we should be looking at to better assess and potentially measure wellbeing, yet the connection and correlation of the data obtained from the LA tool with the specific wellbeing indicator still seemed unclear, a challenge both groups exposed in the evaluation of their co-designed tool. Group 1 went a step further and brought ethics onto the table by stating that even though measuring wellbeing might be a hard feat, there are some technologies that could be used, i.e., hardware sensors, but their risk was high due to their intrusive nature. They came forth with a second scenario where the measurement of wellbeing could be done by using NLP and direct student feedback, but the precision factor gets greatly affected, unlike the first scenario with hardware sensors. However, they exposed this second scenario as more achievable at least in the short run.

Another element of high importance brought forth by Group 2 is theory on how to measure positive feelings, which leads us to an even more complex challenge: how do we automate the measurement of positive feelings (and wellbeing for that matter) through LA tools without compromising neither the precision of the results nor the ethical aspects of teachers and students?

It is important to indicate that the IEEE P7010 WIA approach does not tackle neither the harms that can be induced by the misuse of data, nor the data agency principles such as privacy and fairness. Hence, the process of data collection and management for the use of IEEE P7010 recommended practice can itself have negative impacts on wellbeing. Therefore, other codes and guidelines (e.g., data protection regulations such as GDPR in Europe, IEEE P7003TM Standard for Algorithmic Bias Considerations) must be followed in conjunction with the application of this standard to address ethical considerations related to data agency.

7.1. Future Work

The continuation of this work for each tool includes collecting objective data through more user engagement, identifying data sources to detect wellbeing issues beyond positive feelings, and creating a wellbeing dashboard. This dashboard should be designed in a fashion where data over time is integrated to provide useful, timely and relevant wellbeing information based on the indicators selected in the earlier phases. Such for monitoring, management, and improvement of the tool to help safeguard wellbeing.

Yet, this approach can be restricted by practical challenges and faced by philosophical arguments that find it difficult to avoid negative impacts through better design of technology and urge to direct these efforts toward training users on healthy and positive use of technology. On a practical level, identifying data sources and analytical techniques for questions such as: how to measure students' and teachers' satisfaction, stress, capability, and belonging in LA-supported learning environments is an area that requires further research.

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CHAPTER 3- TEACHERS' VIEWS ABOUT THE IMPACT OF LEARNING DESIGN COMMUNITY PLATFORMS ON WELL-BEING

This chapter is related to the third objective of this thesis that aims at offering examples of the potential well-being impact of LA-supported educational technologies. In the following section, the impact of a learning design community platforms on teachers' well-being was explored through a Likert scale developed based on the well-being indicators selected in Chapter 1. This section is a detailed version of study 3 in the journal article in section 2.3. That article was invited based on the following study in section 3.1.

3.1. Teachers' views about the impact of Learning Design Community platforms on Well-being

The content of this section is published in the proceedings of the 23th International Symposium on Computers in Education (SIIE 2021):

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Research Objectives

[OBJ_1] To identify indicators useful for assessing the digital well-being of LA-supported educational technologies.

[OBJ_2] To explore data collection and analytical techniques that contribute to the assessment of the impact of LA-supported educational technologies on well-being.

[OBJ_3] To offer examples of possible impacts of LA-supported educational technologies on student and teacher well-being.

RQ1.1 *Where and how can LA-supported educational technologies impact well-being?*

RQ1.2 *How much and in which circumstances/areas is the term well-being used in TEL research?*

RQ1.3 *To what extent does the use of IEEE P7010 well-being metrics increase the awareness of educational technologists about their tools' well-being impact?*

RQ2.1 *What data collection and analytical techniques are useful to study affective well-being in the use of ANALYZE, TAP and PyramidApp?*

RQ2.2 *How valid is METUX TENS-Interface questionnaire as an instrument for measuring students' psychological well-being in the use of PyramidApp?*

RQ3.1 *How do teachers perceive the impact of ILDE on their well-being?*

RQ3.2 *What are the possible impacts of PyramidApp on learner and teacher well-being?*

RQ3.3 *To what extent are the students' basic psychological needs of competence, relatedness and autonomy are satisfied by PyramidApp's interface?*

RQ3.4 *What are the triggers of teacher-perceived stressful moments when orchestrating collaborative learning using PyramidApp?*

RQ3.5 *What orchestration actions can be related with teacher-perceived stressful moments when orchestrating collaborative learning using PyramidApp?*

Teachers' views about the impact of Learning Design Community platforms on Well-being

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***Abstract*— Since their first advent, digital technologies have been connected to ethical questions and concerns about their impact on people's lives and the well-being of individuals and communities. This case study belongs to a broader framework where we apply an iterative process guided by IEEE P7010-2020 standard for Well-being Impact Assessment to a set of data-driven educational technologies to evaluate their impacts on well-being by collecting subjective and objective data from creators and users. In this paper, we survey teachers from Saudi Arabia (n=68) to investigate their views about the impact of learning design community platforms supported by learning analytics on their well-being based on well-being indicators distributed to twelve domains. The participants identified several possible well-being impacts that are well-aligned with the creators' views. Yet, the potential negative well-being impacts indicated by the studied tool's creators were less likely to occur from the users' perspective.**

Keywords*— Well-being, Learning Design, Community Platforms, Ethics, Values

I. Introduction

The world of information is today mediated by digital technologies where the growing involvement of data analytics and Artificial Intelligence (AI) in everyday life and their increasing influence on society are likely to present issues with lasting consequences. The individual and societal well-being is becoming intimately connected with the state of our information environment and the digital technologies that underpin our life experiences [1], while global efforts toward evaluating the different impacts of such technologies on human well-being continue to establish guidelines and metrics for such systems to remain human-centric, serving humanity's values and ethical principles. These efforts include two recent productions by the Institute of Electrical and Electronics Engineers (IEEE) under the umbrella of the IEEE global initiative on Ethics of Autonomous and Intelligent Systems (A/IS) that can provide guidance to well-being researchers as well as those creating and using automated data analytics and AI solutions [2]. These two efforts are a chapter on well-being in a publication entitled Ethically Aligned Design (EAD) [3] and a standard entitled P7010–2020 Recommended Practice for Assessing the Impact of Autonomous and Intelligent Systems on Human Well-being, 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 [4].

While AI methods and algorithms are becoming more involved in how decisions are made in public and private life, the presence of this shift in the field of education is represented by various forms of analytics being conducted on data generating from educational systems and academic technology infrastructure for the purpose of understanding and enhancing learning. Consequently, the collection and use of educational data pose a range of ethical issues, including the location and analysis of data; informed consent, privacy and de-identification of data; and the classification and management of data [5], [6]. Other ethical questions are being tackled by researchers in the field of Learning Analytics (LA) raise thorny questions about how and what data are dealt with in educational environments and extend to societal topics like transparency, trust, fairness, accountability, and social well-being [7], [8], [9], [10]. However, there is a research gap in considering the potential of LA to impact the well-being of learners and teachers from a holistic perspective in ways that go beyond enhancing learning outcomes.

Our work in this paper belongs to a broader framework where we apply an iterative process guided by the IEEE P7010-2020 standard to a set of educational technologies to evaluate their impacts on the well-being of the intended users and stakeholders by these technologies. The particular focus of this paper is to investigate teachers' views about the impact of learning design community platforms on twelve domains of their well-being. To do so, we surveyed 68 Saudi teachers to reflect on well-being indicators selected systematically in a previous stage by researchers involved in creating similar tools [11]. In the following sections, we first briefly review the terms of digital well-being and its implications in the field of education and define learning design community platforms. Second, 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 using IEEE P7010-2020 well-being indicators to evaluate LA-supported technologies.

II. Theoretical backgrounds

A. Ethics of Digital Well-being

Since their first advent, digital technologies have been connected to ethical questions and concerns about their impact on people's lives and the well-being of individuals and communities. 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 [12]. Well-being refers to what is directly or ultimately good for a person or population, and it is not limited to one or two dimensions, but rather encompasses the full spectrum of personal, social, and environmental factors that enhance human life and on which human life depends [3].

To the extent that data analytics and AI techniques add to digital technologies in terms of capability and impact, they

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add a heavy burden of ethical concerns that are more crucial than ever before. The field of education was like many other sectors affected by the increasing use of digital technologies and thus by the technological pathways opened by the flow of data from such technologies. Big and small data techniques are being presented and used in the field of Education in the form of Learning Analytics (LA), which is defined as 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]. As the use of LA has increased, a variety of ethical considerations have covered critical data-related issues like privacy and protection and have extended to other important societal values. However, a significant research gap remains in considering the potential of LA to impact the well-being of learners and teachers from a holistic perspective in ways that go beyond the educational scenarios. A recent review on the theme of digital well-being [1] identify major issues related to four key domains, including education, where digital technologies have increasing roles and impacts, and refer to some articles discuss how some digital technologies could support lifelong learning and openness to new opportunities [14], how gamification-based learning could improve cognitive skills [15]; and how smartphones could automatically detect moods and help with work-life balance and management through increased awareness of stress and emotional understanding [16].

B. Learning design community platforms

Learning design is defined as "the creative and deliberate act of devising new practices, plans of activity, resources and tools aimed at achieving particular educational aims in a given context" [17]. Learning design community platforms are web-based 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 in these environments by data-driven systems that assist the lesson planning with data analytics and pedagogical guidelines.

III. Method and Previous Work

This work is connected to an ongoing iterative process being conducted to evaluate the potential positive and negative impacts of selected LA-supported educational technologies on human well-being [11]. The main question we tackle in this process is: Where and how can educational technologies impact well-being? And how can learning analytics be integrated to help safeguard teacher and student well-being?

To answer this question, we apply the IEEE P7010-2020 recommended practice for Well-being Impact Assessment WIA [4], a methodology and a set of metrics, to a set of cases of educational tools that seek different goals and users. A type of LA-supported educational technologies considered are web-based learning design community platforms with integrated lesson planning tools that support teachers in the creation, co-creation, and sharing of designs of learning activities. In this paper, we survey 68 teachers to help answer the first part of the question above, focusing on learning design community platforms had been assessed subjectively by five creators of similar tools. We attempt to examine the creators' views and contrast them with the views of users. Thus, the particular question we tackle in this study is:

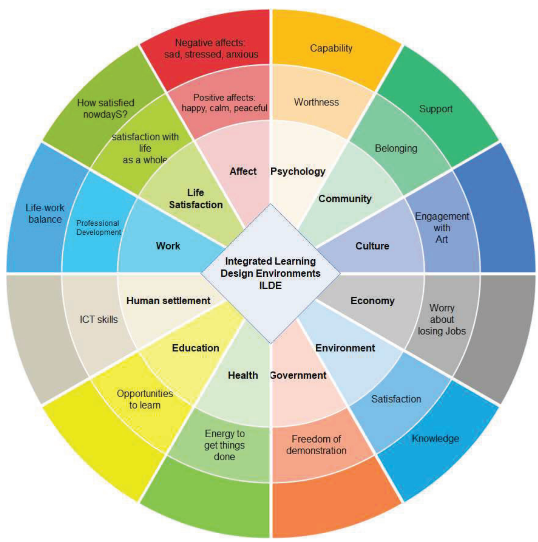
- Where and how can learning design community platforms impact teacher well-being?

A. IEEE p7010 Well-being Impact Assessment

As a methodology, WIA 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. This paper is related to the first activity, where subjective and objective data are collected from the creators and the users of each technology to allow its digital well-being to be comprehensively evaluated and improved. The completed work includes an internal analysis conducted by engaging researchers and engineers who created the studied systems in the first task of the IEEE p7010-2020 recommended practice to help identify where these systems would increase or decrease well-being [11]. The IEEE P7010 recommended practice provides 134 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 a wide range of data-driven technologies on each of the following well-being domains: life satisfaction, affect (feelings), psychological well-being, community, culture, education, economy, environment, government, health (physical and mental), human settlement, and work.

The initial internal analysis that we previously conducted was a systematic process designed by IEEE P7010 creators to be applied by the systems developers allowing them to select well-being indicators to identify the areas of well-being impact of each system based on its goals and population of users. The internal analysis of five learning design community platforms resulted in selecting 29 well-being indicators to reflect intended and unintended, positive and negative impacts of learning design communities on the of well-being of the direct users (teachers) and the indirect stakeholders (students). This study focuses only on teachers, so we drive the 37 questionnaire items in Table 1 from well-being indicators was selected to reflect well-being impacts on this type of stakeholders [figure 1].

Figure 1: well-being indicators selected by tool's creators



B. Data Collection and Participants profile

As this paper aims to investigate the possible well-being impacts of learning design community from the perspective of the intended users of such tools, the invitation to participate in this study was spread among teachers of all levels in Saudi Arabia. They have been teaching and working online due to the Covid-19 restrictions since February 2020 until the end of this academic year in June 2021, allowing them to be more willing now to accept the use of digital tools to support their tasks (beyond only the actual teaching to students, but also lesson planning, collaborating with colleagues, etc.) We arranged a one-hour online session, where 78 teachers were presented to a demo of a specific online learning design community, explaining all its uses and features. Although the tool we demonstrated was a prototype with usability challenges, the participants were able to reflect on it based on not only the extended details provided in the demo, but also on their experience with similar tools and services provided by their educational systems to support them in the novel virtual learning and teaching environment.

Among the attendants, 68 participants (56 females and 12 males) confirmed the consent to participate in the study and completed a questionnaire of 37 Likert items where they were asked to agree or disagree with statements drawn from the IEEE P7010 well-being indicators. About 37% of the participants (25 out of 68) were high school teachers, 35% were primary teachers, 18% were intermediate teachers, and only 7 of the participants (10%) were university instructors. About 66% of the participants have been teaching for more than 15 years, while 16% and 15% of them have been teaching for between 11 and 15 years and between 6 and 10 years, respectively. Only two of them (3%) have less than five years of teaching experience. The responses to the survey have started to arrive 25 minutes after the end of the session and the last response received was about four days later. The video tutorial of the tool was presented in Arabic and has been uploaded to be accessible by the participants after the session.

The survey items in Table 1 were based on scientifically valid well-being indicators driven from IEEE P7010 and include statements that tackle both positive and negative well-being impacts based on hypothesis from the creators' views when they had conducted the internal analysis and selected the indicators. In the cases of assuming both types of impact may occur in different ways and for independent reasons, we formulate two items from the same indicator. For example, from the psychological well-being indicator "Feeling that the things one does are worthwhile" we developed the Likert items: "The use of the tool can make me feel that the things I do are worthwhile" and "The use of the tool can make me feel that the things I do are worthless". The format of each five-level item was as follows: 1. Strongly disagree, 2. Disagree, 3. Neither agree nor disagree, 4. Agree, 5. Strongly agree. It allows the participants to indicate no potential impact when they select the choice number 3. In Table 1, The column of "Agree" represents the percentage of participants who selected 4 and 5, and the "Disagree" column represents the percentage of participants who selected 1 and 2. In Table 2, the positive impact is the average of agreements with positive statements and disagreements with negative statements within a specific well-being domain, while the negative impact is represented by the average of disagreements with positive statements and agreements with negative ones (Tables 1 & 2).

IV. FINDINGS

A. Impacts on Life Satisfaction, Affect and Psychology

About 70% of the participants agree that the use of the tool holds potential positive impact on their feeling of life satisfaction, while only 14% indicate that the use of the tool may make them feel unsatisfied with their life. Also, around 66% agree that positive feelings like happiness and calmness can be driven from the use of the tool, while the negative feelings of sadness, dissatisfaction, anxiety, stress, and frustration are indicated as potential outcomes of using the tool by about 16% of the participants. For psychological well-being, about 79% find positive impact of the tool on their feeling that what they do is worthwhile and that they are capable at what they do, while 11% indicate negative impacts on these aspects of psychological well-being.

Table 1: Teachers' answers on the questionnaire (n=68)

Well-being domain	**Survey items** **Using the platform can:**	**Agree**	**Disagree**
Life satisfaction	increase my satisfaction with life	64.7%	14.7%
	decrease my satisfaction with life	13.2%	76.4%
Affect	make me feel happy	48.5%	20.6%
	make me feel sad	11.7%	79.4%
	make me feel calm	67.6%	20.6%
	make me feel stressed	16.2%	59.2%
	make me feel frustrated	8.8%	75%
Psychological well-being	make me feel that things I do are worthwhile	75%	8.9%
	make me feel that things I do are worthless	13.2%	78%
	make me feel that I am capable at what I do	79.4%	13.2%
	make me feel that I am not capable at what I do	10.3%	82.3%
Community	make me feel that I belong to a community	75%	8.9%
	make me feel that I am rejected by a community	5.9%	85.3%
	increase the approximate total hours a month I was involved in voluntary activities	63.2%	14.7%
	make me feel that if I were in trouble, I would have relatives or friends I can count on to help me whenever I need them	45.6%	33.8%
	make me feel that I can trust people	57.3%	13.2%
	make me feel that I need to be careful in dealing with people	32.3%	27.9%
Culture	increase my chances to engage with / participate in arts or cultural activity	72.1%	11.8%
Economy	increase the degree to which I am worried about losing my job	11.8%	76.4%
	decrease the degree to which I am worried about losing my job	64.7	16.2%
Environment	increase the degree to which I am satisfied with efforts to preserve the environment	70.6%	8.8%
	increase my knowledge about global warming or climate change	54.4%	17.7%
Government	make me feel that there is a space for freedom of assembly, demonstration, and open discussion	63.2%	11.8%
Health	make me feel energetic and able to get things done	70.6%	13.2%
	make me feel lethargic and not being able to get things done	13.2%	72.1%
Education	increase my opportunities to learn	82.4%	10.3%
Human settlement	enhance my ICT skills	83.8%	7.4%

Well-being domain	Survey items	Agree	Disagree
	Using the platform can:		
Work	increase my satisfaction with job	73.5%	10.3%
	decrease my satisfaction with job	17.6%	75%
	make me feel that my work life is interesting	76.5%	11.7%
	make me feel that my work life is uninteresting	16.2%	76.5%
	make me feel that my supervisors have respect for and care about my welfare	60.3%	16.2%
	make me feel that I get help and support from my co-workers	69.1%	13.2%
	enhance my work productivity	70.1%	14.8%
	increase my satisfaction with the balance between the time spent on the job and the time spent on other aspects of life	63.2%	13.3%
	decrease my satisfaction with the balance between the time spent on the job and the time spent on other aspects of life	17.7%	61.8%
	increase my satisfaction with the opportunities for professional development and promotion in my current primary job	73.5%	13.2%

B. *Impacts on Social and Cultural Well-being*

The indicators used to tackle the impact on the domains of community (social well-being) and culture are distributed to the dimensions of belonging, discrimination, community participation, social support, safety, and participation in cultural activity (i.e., art). The reflection on the impact on social well-being include about 75% of the participants agree with potential positive impact on their sense of being a part of a community (i.e., community of teachers), but only 46% believe that they can rely on other members of the community to provide the help and support they need when being in trouble. Also, about 63% consider the use of the platform useful in increasing the approximate total hours a month they are active in voluntary activities, and about 57% find a positive impact of the tool on their sense of trust in each other, against about 31% believe that they need to be careful in dealing with people in such environments. The average of positive reflections on social well-being is about 59%, while about 18% indicate negative impacts on the social aspects above. Finally, one indicator was used to reflect the impact on cultural well-being, resulting in about 72% of the participants find the tool impactful in a positive way on the opportunities they may have to engage with arts or cultural activities.

C. *Impacts on Economic, Environmental and Governmental Well-being*

The indicator we used to investigate possible impacts on the economic well-being of the users was related to the dimension of "jobs", where about 85% (71% positive and 14% negative) agree that the tool may impact its users in the sense of one being worried about losing her job or not finding one. The indicators used to reflect possible impacts of the tool on the well-being domain of environment were the satisfaction with the efforts to preserve the environment and the knowledge about global warming and climate change. About 63% of responses indicate potential positive impacts on these two aspects against 12% for the possible negative impacts. In the case of the government well-being domain, about 64% find that the tool may have a positive impact on their sense of freedom of assembly, demonstration, and public discussion, while about 11% believed the opposite.

D. *Impacts on Health*

The indicator used to reflect possible impacts on the domain of health was related to the sense of having enough energy to get things done. About 71% of the participants find the use of the tool may positively impact them in this regard, while about 13% find that it can lead them to a feeling of lethargy and tiredness.

E. *Impacts on Education and Work Well-being*

The two indicators used to reflect impacts on the two well-being domains of education and human settlement were both related to lifelong learning, where about 83% of the participants find the tool useful to increase their opportunities to learn new things and improve their ICT skills.

The well-being domain of work was tackled through the two dimensions of workplace environment and work-life balance. The participants' views on the tool's impact on workplace environment include about 74% find the tool potentially useful in increasing their job satisfaction and allowing them to see their current work life as an interesting one, against about 15% believe the opposite. About 76% of the participants (60% positive and 16 negative) find the tool relevant to the sense of having supervisors who respect and care about teachers' welfare. In the same venue, about 69% of the participants agree that the tool may hold a positive impact on their sense of getting help and support from co-workers, against 13% perceive this impact as a negative one. Also, 70% consider the tool among the conditions that allow one to be about as productive as one could be, against 15% consider it harmful to their productivity. On the level of life-work balance, about 63% find that the tool supports their ability to balance between life and work and positively impact their feeling of satisfaction in this regard, while 13% do not believe so and indicate a negative impact on this aspect. Finally, about 74% of the participants recognize the tool positively impactful on their satisfaction with opportunities for professional development and promotion in their jobs, against 13% find it impactful in a negative way.

Table 2: Summary of teachers' views about the impact of the platform on each well-being domain (n=68)

Well-being domain	Positive impact	Negative impact
Life satisfaction	70.55%	13.63%
Affect	65.94%	15.85%
Psychological well-being	78.68%	11.4%
Community	59.05%	18.13%
Culture	72.1%	11.8%
Economy	70.55%	14%
Environment	63.2%	11.8%
Government	63.64%	10.61%
Health	71.35%	13.2%
Education	82.4%	10.3%
Human Settlement	83.8%	7.4%
Work	70%	14.42%

V. DISCUSSION AND CONCLUSION

We investigate in this study the teachers' views about the impact of web-based learning design community platforms on twelve domains of human well-being. We survey 68 teachers by using well-being indicators from the IEEE P7010-2020 recommended practice for Well-being Impact Assessment, that were selected based on internal analysis conducted by researchers involved in creating and managing such tools. The teachers' views are, to a considerable extent, well aligned with the hypotheses put by the systems' creators of potential intended and unintended positive impacts of these tools on different dimensions of teacher well-being. However, they do not align with the hypotheses of negative impacts, neither the ones suggested by the systems' creators nor those ones added by us to balance the survey. A possible reason for this could be the differences on the levels of criticism and awareness of harms between the systems' creators (i.e., researchers) and the users (i.e., teachers). In the stage preceding this study, the researchers had attempted to adhere to the IEEE P7010 internal analysis regarding the rigor of their assessment of the well-being impacts, by assuming several scenarios of varying likelihood of occurrence, some of which are found unlikely by the users. For example, the researchers find that the negative feelings of anxiety and frustration 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, while most of the teachers in this study do not report such possibilities.

It is important to indicate that the WIA approach is limited to assess the well-being impact based on a range of well-being indicators that can be relevant to various data-driven digital technologies, but not to many others. Moreover, the approach does not tackle neither the harms that can be induced by the misuse of data, nor the data agency principles such as privacy and fairness. Hence, the process of data collection and management for the use of IEEE P7010 recommended practice can itself have negative impacts on well-being. Therefore, other codes and guidelines (e.g., data protection regulations such as GDPR in Europe, IEEE P7003TM Standard for Algorithmic Bias Considerations) have to be followed in conjunction with the application of this standard to address ethical considerations related to data agency. Overall, the process of identifying well-being impacts based on subjective and objective reflections on selected well-being indicators represents only an initial step and a starting point toward full consideration and evaluation of the impact of learning technologies on well-being, including finding data sources that are useful to detect well-being issues, and design of technical intervention toward better well-being impacts of data-supported learning technologies.

Acknowledgment

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CHAPTER 4- UNDERSTANDING THE WELL-BEING IMPACT OF A COMPUTER-SUPPORTED COLLABORATIVE LEARNING TOOL: THE CASE OF PYRAMIDAPP

This chapter is composed of four sections that tackle parts of all the three objectives of this thesis through evaluating a CSCL case. In section 4.1, a cycle of the IEEE P7010 first activity was conducted to map the use of PyramidApp to well-being domains and indicators. The tool's developers and samples of its users participated in surveys and interviews to provide initial insights on the scoped area of PyramidApp's well-being impact. Based on the findings obtained, the sections 4.2 and 4.3 present and discuss the findings of data collection scenarios that were carried out to study students' basic psychological needs satisfaction when dealing with PyramidApp's interface (section 4.2), and the triggers of teacher-perceived stressful moments when orchestrating collaborative learning activities facilitated by PyramidApp (section 4.3).

4.1. Understanding the Well-Being Impact of a Computer-Supported Collaborative Learning Tool: The Case of PyramidApp

The content of this section is published in the proceedings of the 17th European conference of Technology-enhanced Learning (EC-TEL 2021):

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Research Objectives

[OBJ_1] To identify indicators useful for assessing the digital well-being of LA-supported educational technologies.

[OBJ_2] To explore data collection and analytical techniques that contribute to the assessment of the impact of LA-supported educational technologies on well-being.

[OBJ_3] To offer examples of possible impacts of LA-supported educational technologies on student and teacher well-being.

RQ1.1 *Where and how can LA-supported educational technologies impact well-being?*

RQ1.2 *How much and in which circumstances/areas is the term well-being used in TEL research?*

RQ1.3 *To what extent does the use of IEEE P7010 well-being metrics increase the awareness of educational technologists about their tools' well-being impact?*

RQ2.1 *What data collection and analytical techniques are useful to study affective well-being in the use of ANALYZE, TAP and PyramidApp?*

RQ2.2 *How valid is METUX TENS-Interface questionnaire as an instrument for measuring students' psychological well-being in the use of PyramidApp?*

RQ3.1 *How do teachers perceive the impact of ILDE on their well-being?*

RQ3.2 *What are the possible impacts of PyramidApp on learner and teacher well-being?*

RQ3.3 *To what extent are the students' basic psychological needs of competence, relatedness and autonomy are satisfied by PyramidApp's interface?*

RQ3.4 *What are the triggers of teacher-perceived stressful moments when orchestrating collaborative learning using PyramidApp?*

RQ3.5 *What orchestration actions can be related with teacher-perceived stressful moments when orchestrating collaborative learning using PyramidApp?*

Understanding the Well-Being Impact of a Computer-Supported Collaborative Learning Tool: The Case of PyramidApp

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Abstract. The global efforts toward evaluating the impact of the use of data-driven technologies on humans' well-being continue to establish societal guidelines for such systems to remain human-centric, serving humanity's values and safeguarding well-being. In this paper, we apply the first activity of IEEE P7010 recommended practice, a methodology and a set of metrics, to understand the well-being impact of a web-based tool (PyramidApp) that allows teachers to design and deploy Pyramid-pattern based collaborative learning activities in classroom learning scenarios. The tool's creators who are learning technology researchers (n = 2) and a sample of the tool's users and stakeholders who are undergraduate students (n = 11), master students (n = 14) and instructors (n = 2) are engaged in surveys and interviews to investigate the tool's well-being impact by reflecting on well-being indicators distributed to multiple well-being domains. The findings discuss possible impacts of the tool on the well-being domains of life satisfaction, affect, psychological state, community, education, government, human settlement and work. The creators also share views about the extent to which the use of IEEE P7010 increases their awareness of the intended and unintended impacts of their tool on well-being.

Keywords: Well-being · Computer-Supported Collaborative Learning · Ethics · Values

1 Introduction and Background

Given the rapid emergence of Information and Communication Technologies (ICT) and their increasing adoption by individuals and societies, personal and societal well-being are now inextricably linked with the state of our information environment and the digital technologies that mediate our interaction with it [1]. With the growing role of data analytics and Artificial Intelligence (AI) techniques in this digital space, the global efforts toward evaluating the different impacts of digital technologies continue to establish guidelines and metrics for such systems to remain human-centric, serving humanity's values and safeguarding well-being [e.g., 2, 3]. Well-being refers to what is directly or ultimately good for a person or population, and it is not limited to one dimension, but

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rather encompasses the full spectrum of personal, social, and environmental factors that enhance human life and on which human life depends [2]. The expression "digital well-being" is used to describe the impact of digital technologies on what it means to live a life that is good [1], including intended and unintended, positive and negative impacts on all well-being dimensions.

Computer-Supported Collaborative Learning (CSCL) is an interdisciplinary field of research that aims to investigate how learners engage in collaboration with the help of computers. Some of the well-known examples of CSCL scripts include Pyramid, Jigsaw, Think-Pair-Share (TPS), and Thinking Aloud Pair Problem Solving (TAPPS) [4]. Pyramid scripts integrate activities occurring at multiple social levels. First, learners will study a given problem individually to propose an initial solution. Learners then join in small groups and then increasingly larger groups to discuss their solutions, and to propose a shared solution to the given problem. In this study, a tool called PyramidApp that implements a particularization of the Pyramid pattern has been used to deploy CSCL activities [5]. The tool provides an activity authoring space, a teacher-facing dashboard and an activity enactment space for students. The teacher-facing dashboard not only provided a real-time overview of collaboration but also consisted of different controls, e.g., activity pause-resume, increasing time, and an alerting mechanism that informed critical moments of collaboration to the teachers to support their orchestration actions.

We engage samples of the creators, users and stakeholders of PyramidApp in the first activity of IEEE P7010-2020, a recommended practice to assess the well-being impact of autonomous and intelligent systems [3]. This activity is composed of 1) an internal analysis conducted by the tool's creators where they apply internal analysis techniques (e.g., brainstorming, hypothesizing, utilizing scenarios, etc.) and 2) surveys and interviews with the tools' users and stakeholders, to answer the following question: *What are the possible impacts of PyramidApp on learner and teacher well-being?*

2 Method

IEEE P7010 Well-being Impact Assessment (WIA) is an iterative process that aims at producing a well-being indicators dashboard and using it in the design, development, deployment and continual improvement of data-driven tools in order to help safeguard and improve human well-being [3]. 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 instruments already in use (i.e., scientifically valid) to be used to identify impacted well-being areas of a particular data-driven technology on the following domains of well-being: satisfaction with life, affect (feelings), psychological well-being, community, culture, education, economy, environment, government, health, human settlement, and work.

We apply the first activity of this approach with the objective of identifying well-being domains and indicators that can reflect possible impacts of PyramidApp on the well-being of its users and stakeholders (i.e., students and teachers). This activity consists of three tasks: initial analysis, user engagement, and stakeholder engagement. Task 1 is an internal analysis conducted by the tool's creators and involves forecasting, hypothesizing, projecting and utilizing scenarios to select well-being indicators that can reflect the impact of the tool and be used as principles of design during redesign and improvement processes. In the latter two tasks, user and stakeholder engagement, we seek to test the assumptions arriving from task 1.

Table 1. Well-being indicators selected by Sample 1 (creators)

Well-being domains	Well-being indicators	Impacted party		
		Students	Teachers	Society
Life satisfaction	Satisfaction with life as a whole	√	√	
Affect	Calm in a given time period	√	√	
	Stress level in a given time period	√	√	
Psychological well-being	Sense one is capable and good at what they do	√	√	
Community	Sense one sees oneself as part of a community	√		
	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	√		
	Satisfaction with relationships	√	√	
Education	Access to opportunities to learn	√		
Government	Sense there is freedom of assembly, demonstration, and open public discussion	√	√	
Human settlements	Proportion of youth and adults with information and communications Technology (ICT) skills	√	√	√
	Proportion of population covered by a mobile network, by technology			√
	Access to internet at home			√
	Having a computer at home			√
Work	Sense that one gets support and help from co-workers	√		

2.1 Participants and Procedures

The following samples were selected based on convenience sampling, and the interviewed students were selected to represent the different views coming from the survey.

Sample 1. Learning technologies researchers (n = 2) who have co-created PyramidApp and were presented to 134 well-being indicators distributed to 12 well-being domains in a survey manner allowing them to: 1) identify the system and its goals, users, and stakeholders 2) read the definitions and indicators of each well-being domain, and 3) select well-being indicators allocate them to the impacted party (Table 1). Then they were interviewed individually for 30 munities to reflect on the process.

Sample 2. Master students (n = 14) who took part in PyramidApp activities on five occasions. They responded twice to an 11-items Yes/No survey: a) after their last use of the tool immediately, and b) two weeks after their last use of the tool (Table 2). Two of them were interviewed individually for 15 min to provide in-depth answers.

Sample 3. Undergraduate students (n = 11) who took part in PyramidApp activities on five occasions. They responded to a 11-items Yes/No survey two weeks after their last use of the tool (Table 2). Three of them were interviewed to provide in-depth answers.

Sample 4. Instructors (n = 2) who applied PyramidApp activities on many occasions during the last two years. They were interviewed to discuss how the tool could impact their students' well-being and their own well-being as stakeholders of the tool.

3 Findings

As shown in (Table 1), PyramidApp's creators found the tool impactful on eight different well-being domains. These assumptions were well-aligned with the responses of the tool's users (i.e., students) on the 11-item survey (Table 2). The tool's stakeholder (i.e., teachers) also reported such an impact through their answers in the individual interviews. Students and teachers agreed that the time restrictions in PyramidApp activities can cause negative feelings like stress and anxiety, although they stated that it can be a positive level of stress that could encourage students to quickly generate ideas and be fully active during the learning process. On another hand, they reported that the positive feelings of satisfaction, capability and sense of belonging can be obtained due to the competences of freedom of discussion and collaboration, where students can seek and get help and support from each other. The students found the tool impactful on their learning too and reported that their knowledge about the topic under discussion were developed during the activity in a constructive way.

Table 2. Responses to the questionnaire by samples 2 and 3 (students)

Survey items based on Table 1	Sample 2(a) n = 14		Sample 2(b) n = 14		Sample 3 n = 11	
	Yes	No	Yes	No	Yes	No
I'm satisfied with the activity	86%	14%	100%	0%	100%	0%
I was calm during the activity	64%	36%	79%	21%	100%	0%
I was stressed during the activity	43%	57%	21%	79%	0%	100%
During the activity I felt that I was capable at what I'm doing	93%	7%	100%	0%	91%	9%
During the activity I felt that I'm part of a community	93%	7%	86%	14%	45%	55%
During the activity I felt that I belong to a community	43%	57%	64%	36%	45%	55%
During the activity I sense that if I was in trouble, I would have friends I can count on to get help whenever I need them	57%	43%	64%	36%	55%	45%
I'm satisfied with relationships I had with classmates and teacher during the activity	93%	7%	86%	14%	73%	27%
Activity has given me access to learning opportunities	100%	0%	86%	14%	82%	16%
Activity helped to improve my ICT skills	64%	36%	43%	57%	91%	9%
I think the activity has a freedom of assembly, demonstration, and open public discussion	86%	14%	93%	7%	100%	0%

4 Discussion and Future Work

The application of IEEEP7010 standard was considered by the creators of PyramidApp a good start-point toward including the different dimensions of well-being as additional requirements for the tool's evaluation and redesign processes. They found the well-being definitions and indicators provided by this standard rich and informative and that this activity has increased their awareness of the potential well-being impact of their tool and therefore their capacity to address them in the design lifecycle. Samples of the tool's users and stakeholders had views that were to a considerable extent well-aligned with the creators' ones regarding both positive and negative well-being impacts.

The continuation of this work includes identifying data sources to detect well-being issues to be used in creating a well-being dashboard that should be designed and continuously refined in a fashion where data over time is integrated to provide useful, timely and relevant well-being data based on the indicators selected in this phase. Such for monitoring, management and improvement of the tool to help safeguard well-being.

Yet, this approach can be restricted by practical challenges and faced by philosophical arguments that find it difficult to avoid negative impacts through better design of technology and urge to direct these efforts toward training users on healthy and positive use of technology. On the practical level, questions need to be addressed before moving forward include: What data sources are useful to measure students' senses of satisfaction, stress, capability and belonging in a computer-supported collaborative learning environment?

Acknowledgement. This work has been partially funded by the EU Regional Development Fund and the National Research Agency of the Spanish Ministry of Science and Innovation under project grants TIN2017-85179-C3-3-R, PID2020-112584RB-C33. D. Hernández-Leo (Serra Húnter) acknowledges the support by ICREA under the ICREA Academia program. E. Hakami acknowledges the grant by Jazan University, Saudi Arabia.

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4.2. Students' Basic Psychological Needs Satisfaction at the Interface Level of a Computer-Supported Collaborative Learning Tool

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RQ3.4 *What are the triggers of teacher-perceived stressful moments when orchestrating collaborative learning using PyramidApp?*

RQ3.5 *What orchestration actions can be related with teacher-perceived stressful moments when orchestrating collaborative learning using PyramidApp?*

Students' Basic Psychological Needs Satisfaction at the Interface Level of a Computer-Supported Collaborative Learning Tool

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Abstract. Well-being has been considered an urgent vein of discussion in fields that intersect with Information and Communication Technologies. In this paper, we used a questionnaire adapted from the METUX (Motivation, Engagement, and Thriving in User Experience) model to explore how well a Computer-Supported Collaborative Learning (CSCL) tool's interface satisfy users' needs for competence, autonomy, and relatedness; and to test the instrument's validity in a CSCL context. METUX provides scales grounded in Self-Determination Theory (SDT) allowing researchers to foster insights into how technology designs support or undermine psychological needs, boosting user well-being. 53 bachelor students represented the tool's users based on convenience sampling. Our findings showed that users may not perceive the autonomy construct in the tools' interface, taking a neutral stance toward aspects of competence and relatedness as well. The results indicate the need for design interventions to improve the interface's ease of use, and the components that facilitate interaction and feelings of being connected. Regarding the instrument, more work is needed to validate the use of METUX interface in CSCL, especially for the autonomy subscale. Also, more scales from METUX (e.g., adoption and task spheres of experience) are needed to be included in the future for a fuller validation.

Keywords: Well-being · Computer-supported collaborative learning · Self-determination theory · METUX

1 Introduction

The satisfaction of three basic psychological needs—*competence* (the sense of being capable and effective), *autonomy* (feeling self-governed and self-endorsed) and *relatedness* (feeling connected and interacting)—has been shown to be critical to both motivation and well-being in the field of psychology [1]. According to the Self-Determination Theory (SDT) [2], the satisfaction of these three needs is a universal prerequisite for psychological well-being. SDT theorists [2–5] consider these needs as broad motivational

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inclinations that function throughout life domains and argue that satisfaction of all three needs, as opposed to only one or two, is crucial for well-being [6]. In education, SDT posits that students' intrinsic motivation is rooted in having their basic psychological needs met [3]. Students are actively motivated to engage in learning tasks when pedagogical design appropriately satisfies these psychological needs [7]. The majority of SDT studies in this regard have investigated how the three needs are fulfilled in traditional face-to-face learning [8, 9], with some exceptions discussing SDT in online and digital learning contexts [7, 10]. One current direction of SDT research concerns the potential and challenges associated with the use of technologies in education [11]. More SDT research, according to [11], will undoubtedly be looking at not only how technology-enhanced learning can be designed to motivate engagement and learning [12], but also how teachers and students can be motivated to embrace technology as a tool for learning [13, 14]. In collaborative learning, sense of relatedness is particularly relevant due to the great amount of social interaction involved in collaborative settings. For example, a study by [15] showed that students' sense of relatedness to peers and teachers predicted their engagement level in collaborative writing using wikis.

The past decade has seen a rise in interest in human-centred design, where scholars and practitioners alike have struggled to translate the desire to design for human flourishing and well-being into clear and practical practice. The three basic needs can be utilised as inspirations or parameters to evaluate and enhance a design [13, 16]. Designing with users' psychological needs in mind (i.e., their desire to feel competent and autonomous, as well as their need to feel connected to others) is a key component of the SDT approach [13]. The notion of needs satisfaction implies that designers are required to understand users' expectations regarding the needs and adjust the design to meet those expectations [13]. For example, [17] applied SDT to understand what the three psychological needs entail in conversational agents' experiences. That study obtained insights into users' perceptions and expectations on the three needs, enabling the development of informative recommendations for fulfilling the needs in the design of conversational agents [17].

In this paper, we apply METUX TENS-Interface [13], a measure driven from SDT-based questionnaires, to explore students' perceptions on the extent to which their basic psychological needs are satisfied at the interface level of using PyramidApp, a computer-supported collaborative learning (CSCL) tool. PyramidApp is a web-based tool that enables teachers to design and implement CSCL scripts based on the Pyramid pattern [18]. Within the tool, students engage in collaboration following a Pyramid structure. Students are automatically allocated into small groups first and later into larger groups, facilitating them to reach a consensus to the given task at the end of the script. A teacher-facing dashboard is built into the tool to support teachers in orchestrating collaboration [19]. This work aims at exploring whether the three basic psychological needs are covered by the tool; and validating the used instrument in the tool's context for the purposes of continuous data collection and evaluation. We posit that the use of METUX TENS-Interface questionnaire in CSCL can provide meaningful insights about user autonomy, competence and relatedness; and therefore, inform the design processes in these regards.

The rest of this paper is organised as follows: We review the research context and the studied tool. Then we clarify the methods followed in this research, explaining the previous work and METUX model with a focus on the TENS-Interface questionnaire.

Then we test the scales' validity, visualise and discuss the findings and conclude the paper by describing the implications of design and the future direction of this work.

2 Research Context

2.1 Self-determination Theory (SDT)

Self-determination theory (SDT) posits that basic psychological needs for autonomy, competence, and relatedness must be satisfied for an individual, at all ages, to develop a sense of growth, integrity, and well-being [4, 20]. Experiencing the feeling of effectiveness and mastery is central to the concept of competence. As one effectively completes tasks and encounters opportunities to apply skills and knowledge, this need is fulfilled. Feelings of inefficiency and failure are common responses to competence frustration. Autonomy is the experience of voluntary action, and is satisfied when one's behaviours, thoughts, and feelings are self-endorsed and authentic. When frustrated, one feels pressure, conflict, and being pushed in an undesired direction. Relatedness is the experience of bonding and care, and it is satisfied by feeling connected to others. Relatedness frustration comes with a feeling of being socially isolated and excluded [see 1–20]. There is sufficient evidence from SDT [21–23] that a learning environment that satisfies students' need for autonomy, competence, and relatedness is essential for learners' self-determination and self-regulation. Students' intrinsic motivation, autonomous self-regulation, along with the quality of their performance, are influenced by the extent to which their basic psychological needs are satisfied in their learning environments [1, 4].

2.2 Pyramid Pattern Based CSCL Activities

Computer-Supported Collaborative Learning (CSCL) is an interdisciplinary field of research that aims to investigate how learners engage in collaboration with the help of computers [24]. Although CSCL provides opportunities to connect peers with the use of computers, there is no guarantee that every CSCL situation may create opportunities for productive interactions and therefore learning. To this end, scripts had been proposed as a way to structure collaboration by providing guidance and instructions to students on how to interact during collaboration in Technology Enhanced Learning scenarios [25, 26]. These 'scripts' are known as Collaborative Flow Patterns (CLFPs). Some of the well-known examples of CLFPs include Pyramid, Jigsaw, Think-Pair-Share (TPS), and Thinking Aloud Pair Problem Solving (TAPPS) [27].

Different CLFPs are shaped by the pedagogical rationale and constraints defined by CLFPs themselves [28]. For instance, Pyramid CLFP integrates activities occurring at multiple social levels. First learners will study a given problem individually to propose an initial solution. Learners then join in small groups, usually in pairs to discuss their solutions, and to propose a shared solution at the small group level. The discussion and negotiation will repeat in growing sizes of groups following a Pyramid structure until the whole group reaches a common solution to the given problem. Structuring collaboration according to this pattern provides several educational benefits to students. For instance, it provides equal opportunities for students to express their solutions, to negotiate with their peers, and also as the interactions accumulate across Pyramid levels it promotes positive interdependence. In this study, a tool called PyramidApp that implements a particularisation of the Pyramid pattern has been used to deploy CSCL activities. The tool provides an activity authoring space and a teacher-facing dashboard for the teachers and an activity enactment space for students. The teacher-facing dashboard not only provided a real-time overview of collaboration but also consisted of different controls, e.g., activity pause-resume, increasing time, and an alerting mechanism that informed critical moments of collaboration to the teachers to support their orchestration actions.

2.3 PyramidApp

PyramidApp is a web-based tool that facilitates the implementation of the Pyramid pattern-based collaborative learning activities [19, 28]. The tool is composed of three main components namely: a) activity authoring/design space; b) activity enactment space and c) activity regulation space. As shown in Fig. 1 first in the activity design stage teachers are required to configure several design elements related to the group activity such as the number of students in class, duration of the script phases, and group size. Once designed the activity can be published to generate an automatic URL that can later be shared with students for enactment. Students can use their mobile phones, tables or laptops to join the activity. The tool also provides a teacher-facing dashboard through which the teacher can monitor collaboration and intervene as required.

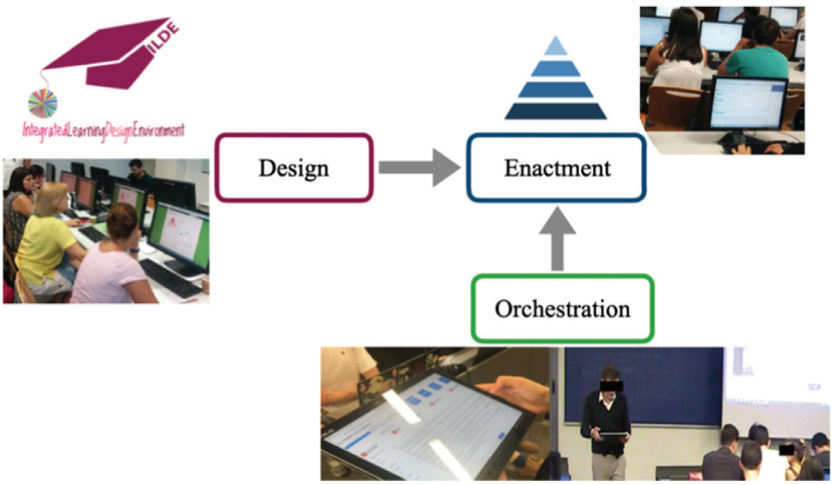

Fig. 1. Different components of PyramidApp

Within the PyramidApp collaboration is structured following a Pyramid structure. After login into the tool, students are required to enter an individual answer to the given problem. At the end of the individual answer submission stage students are randomly allocated into groups where they get an opportunity to see the answers submitted by the fellow group members. At the group levels, students are expected to evaluate the answers from peers. At the end of the voting phase students moved into an option improving phase (see Fig. 2). In this phase students had access to the integrated chat to engage in discussion with peers and a collaborative text editor (see top-left in Fig. 2) that provided a space for students to write an improved option or to reformulate existing options collaboratively. Students were also shown the average ratings received for each option at the previous rating level (see bottom-left in Fig. 2). At the end of the option improving stage students were promoted to agree on the newly formulated option or to promote the previous answers to further evaluate in the next larger group levels (Fig. 3). Also, all the groups are merged to formulate larger groups. Again, in the larger groups within an individual option evaluation stage students first evaluated the selected options from the previous small group levels individually, then engaged in the option improving stage as discussed earlier. At the end of the activity the selected answers are presented to the students.

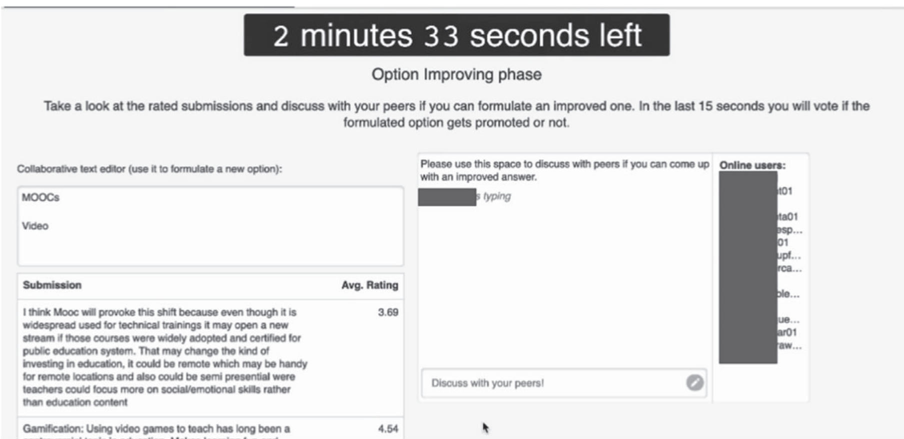

Fig. 2. User interface of the PyramidApp, answer improving space (left), discussion space (right)

Fig. 3. Agreeing on newly formulated options

3 Methods

3.1 Previous Work

The inquiry in this paper belongs to a broader framework where an evaluation process guided by the IEEE P7010-2020 Well-being Impact Assessment (WIA) is applied to evaluate the well-being impact of PyramidApp on its users and stakeholders. As a methodology, WIA 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 [29]. This paper is related to the third activity, aiming at collecting data that can be used to enhance the studied tool's digital well-being. Two of the tool's developers and a sample of the tool's users and stakeholders had participated in surveys and interviews to reflect on a wide range of well-being indicators distributed to multiple well-being domains. The findings discussed possible impacts on the well-being of students and teachers in the areas of life satisfaction, affect (stress), psychological state (sense of capability), community (sense of belonging), education (learning), human settlement (ICT skills), and work (support from peers) [30].

3.2 METUX TENS-Interface

METUX (Motivation, Engagement, & Thriving in User Experience) is a model for bridging Self Determination Theory (SDT) to technology design practice [13]. METUX can be used to evaluate technologies with respect to well-being impact when well-being in this context refers to the "optimal psychological functioning and experience" [31]. The METUX model centres on the well-researched claim [1] that human psychological well-being is mediated by three key constructs: Autonomy (feeling agency, acting in accordance with one's goals and values), Competence (feeling able and effective); and Relatedness (feeling connected to others, a sense of belonging) [13].

METUX proposes that in order to address well-being, psychological needs must be considered within five different spheres of analysis including: at the point of technology *adoption*, during interaction with the *interface*, as a result of engagement with technology-specific *tasks*, as part of the technology-supported *behavior*, and as part of an individual's *life* overall [13]. The data we collect and analyze in this paper is limited to the interface sphere by applying the TENS-Interface questionnaire to a sample of a CSCL tool's student users. When students interact with a learning tool, the satisfaction of the basic psychological needs, via the user interface, predict usability, engagement with technology, and user satisfaction. On the other hand, poor interface usability will cause need-frustration which impacts both engagement and user well-being [13].

3.3 Procedures

A sample of the studied tool's users, 53 first year bachelor students who were enrolled to the same course at a Spanish university, was selected based on convenience sampling. The participants were asked to rate their level of agreement to 15 items using a 5-point Likert scale (1 = Do Not Agree, 5 = Strongly Agree). Each key construct (e.g., competence) was measured through five items. All items are weighted equally in scoring, and reverse-scored items are reverse scored. The participants filled the questionnaire after they finished a task facilitated by the tool. All the participants had used the tool to complete collaborative learning tasks at least on three occasions by the time of filling the survey.

4 Findings

4.1 Validity Statistics

The measures introduced in METUX were externally validated by the model's developers [13], who carried out a pilot validation study in which 400 participants (100 for each of four technologies) were asked to fill out each METUX questionnaire in reference to one of four possible technologies: Facebook, Google Docs, a music streaming service and a fitness band. Results showed satisfactory to good internal consistency for all questionnaires with alphas for subscales ranging from 0.66 to 0.88. Furthermore, some initial support for the METUX model in higher education was provided by [32], who urged the need for additional validation work to improve the scale that measures need-satisfaction in the interface and task spheres of experience.

We conducted a validity analysis on the TENS-Interface questionnaire comprising five items for each subscale to test their validity in a CSCL context. Cronbach's alpha showed that the competence and relatedness subscales reached good internal consistency levels, $\alpha = 0.85$ and $\alpha = 0.80$ respectively. The autonomy subscale failed to reach the minimum accepted value of Cronbach's alpha, which was found at $\alpha = 0.67$ [13] and had a questionable internal consistency of $\alpha = 0.63$.

Inter-item correlations and item-total correlations were calculated for the autonomy subscale to identify problematic items. Most items appeared to be problematic in this subscale, resulting in low inter-correlations and slight decrease in the Cronbach's alpha if the item was deleted. The one exception to this was the third item (i.e., I feel pressured by the tool), which would significantly decrease the Cronbach's alpha if it was deleted and had a higher item-total correlation and more consistently higher inter-item correlations (Tables 1 and 2).

This outcome aligns with the results from the initial analysis conducted by the tool's creators to evaluate its overall well-being impact [30]. The tool had been found impactful on psychological well-being in the sense of capability, social well-being in the sense of belonging, and affective well-being in the sense of stress. The indicator of autonomy had not been found relevant in earlier stages of this evaluation process [30].

4.2 Scale Statistics

The responses of each participant to each 5-item scale were combined by calculating the average score of each participant, then the average score of each scale. The analysis of the participants' responses to the TENS-Interface questionnaire showed that competence was the most satisfied need in the interface of the studied tool (Mean = 3.63), followed by autonomy (Mean = 3.15) and relatedness (Mean = 2.96) (Table 3).

Table 1. Inter-item correlations of autonomy subscale

	The tool provides me with useful options and choices	I can get the tool to do the things I want it to	I feel pressured by the tool	The tool feels intrusive	The tool feels controlling
The tool provides me with useful options and choices	1	0.63	0.30	−0.007	0.008
I can get the tool to do the things I want it to	0.63	1	0.21	0.04	−0.03
I feel pressured by the tool	0.30	0.21	1	0.50	0.50
The tool feels intrusive	−0.007	0.04	0.50	1	0.38
The tool feels controlling	0.008	−0.03	0.50	0.38	1

Table 2. Item-total correlations of autonomy subscale

Item	Item-total correlation	Cronbach alpha if item deleted
The tool provides me with useful options and choices	0.59	0.61
I can get the tool to do the things I want it to	0.55	0.62
I feel pressured by the tool	0.81	0.44
The tool feels intrusive	0.60	0.59
The tool feels controlling	0.61	0.61

Table 3. Descriptive statistics of each subscale

Scale	No. of items	α	n	Mean	Std
Competence	5	0.85	53	3.63	0.79
Autonomy	5	0.63	53	3.15	0.64
Relatedness	5	0.80	53	2.96	0.73

4.3 Visualization

In order to have a global overview of the data, we visualised it in a compact representation through different colours in a percentile system, making it easier to visually digest and compare (Figs. 4, 5 and 6).

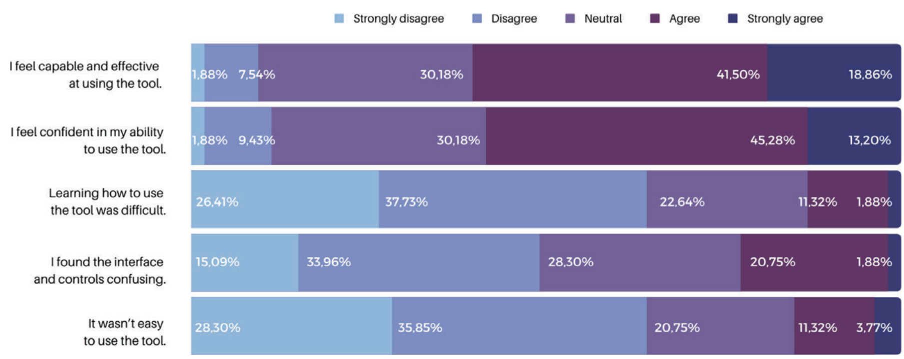

Fig. 4. Competence

5 Discussion and Future Work

SDT research and applications have grown significantly over the past two decades, with diverse interests in the relationship between the theory and practice in educational

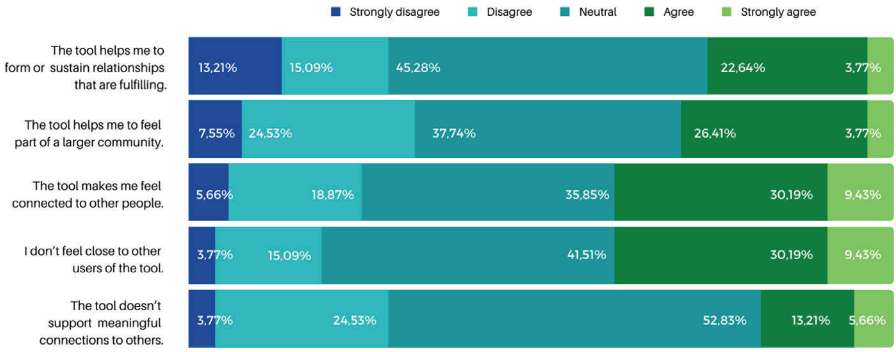

Fig. 5. Relatedness

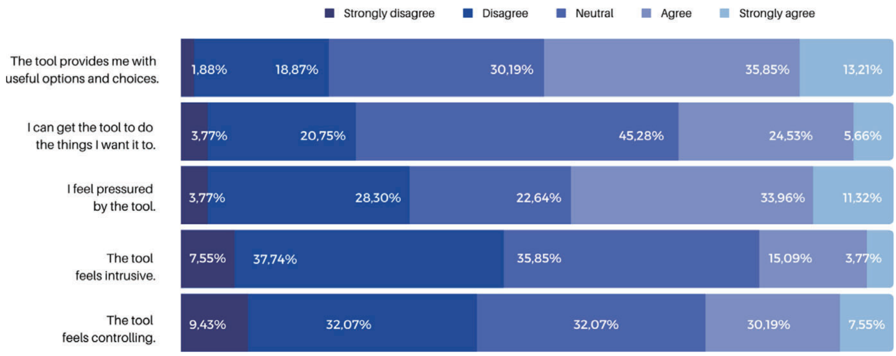

Fig. 6. Autonomy

contexts. In this paper, we explore how students' basic psychological needs for autonomy, competence, and relatedness are supported by the interface of a CSCL tool. The responses of 53 students who used the tool to complete collaborative learning tasks reveal that the value of autonomy is not as well defined as competence and relatedness in the interface of the studied tool. The internal consistency of the autonomy scale was questionable ($\alpha = 0.63$), indicating that the user may not clearly perceive this construct while dealing with the tool's interface. Some aspects of the relatedness construct (i.e., sustainable relationships and meaningful connections to others) are not well perceived as about half of the participants hold a neutral position towards them being supported in the tool's interface (Fig. 2). In addition, a third of the participants are neutral towards all of the competence aspects, indicating the need for design interventions to improve the interface's ease of use.

As for the TENS-Interface instrument itself, the low level of consistency in results we obtained in the Autonomy component might be due to the way the 5 questions are posed, since the questions can be perceived as generic, especially when the tool has a number of functionalities that we think should be evaluated separately for fuller insight on the true impact the interface has on the autonomy need. Thus, as part of our future work we propose to adapt the questions to each interface element or functionality, rather than compacting them all under the interface as a whole. As a step in this direction (specific to our tool), we propose to iterate the autonomy component of the TENS-Interface instrument, adapting it to the specific elements of the interface before proposing any tool design decisions in regard to autonomy need satisfaction.

On the other hand, related to the two remaining basic psychological needs, and based on the obtained results, since we find that competence was the most satisfied need in the interface of the studied tool (Mean = 3.63), we shift our focus to relatedness (Mean = 2.96), which was the least satisfied need. The design implications regarding the relatedness need are to be focused on tool components that facilitate students' interaction and feelings of being connected (i.e., chat, co-editing space and other collaborative components of the interface). The design improvements are to be evaluated by the same TENS-Interface questionnaire.

Overall, we presume that the TENS-Interface instrument requires further improvements before it can be utilized and applied to specific CSCL scenarios. We propose a first improvement in that regard: define the different functionalities of the interface first, then adapt the questions of the three components (autonomy, competence, relatedness) to each one of these functionalities, instead of relying solely on the interface as a whole. This will undoubtedly result in a longer questionnaire, but the results will be just as specific and detailed. Another positive aspect is that there will be more clarity on which components of the interface truly fulfil the three needs and which ones do not.

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4.3. Triggers of teacher-perceived stressful moments when orchestrating collaborative learning with technology

The content of this section is submitted to 16th International Conference on Computer-Supported Collaborative Learning (CSCL 2023)

Hakami, E., Hakami, L., Amarasinghe, I., Hernández-Leo, D.: Triggers of teacher-perceived stressful moments when orchestrating collaborative learning with technology. Submitted to the International Conference on Computer-Supported Collaborative Learning (CSCL 2023)

Research Objectives

[OBJ_1] To identify indicators useful for assessing the digital well-being of LA-supported educational technologies.

[OBJ_2] To explore data collection and analytical techniques that contribute to the assessment of the impact of LA-supported educational technologies on well-being.

[OBJ_3] To offer examples of possible impacts of LA-supported educational technologies on student and teacher well-being.

RQ1.1 *Where and how can LA-supported educational technologies impact well-being?*

RQ1.2 *How much and in which circumstances/areas is the term well-being used in TEL research?*

RQ1.3 *To what extent does the use of IEEE P7010 well-being metrics increase the awareness of educational technologists about their tools' well-being impact?*

RQ2.1 *What data collection and analytical techniques are useful to study affective well-being in the use of ANALYZE, TAP and PyramidApp?*

RQ2.2 *How valid is METUX TENS-Interface questionnaire as an instrument for measuring students' psychological well-being in the use of PyramidApp?*

RQ3.1 *How do teachers perceive the impact of ILDE on their well-being?*

RQ3.2 *What are the possible impacts of PyramidApp on learner and teacher well-being?*

RQ3.3 *To what extent are the students' basic psychological needs of competence, relatedness and autonomy are satisfied by PyramidApp's interface?*

RQ3.4 *What are the triggers of teacher-perceived stressful moments when orchestrating collaborative learning using PyramidApp?*

RQ3.5 *What orchestration actions can be related with teacher-perceived stressful moments when orchestrating collaborative learning using PyramidApp?*

Triggers of teacher-perceived stressful moments when orchestrating collaborative learning with technology

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Abstract: Teachers' well-being may be negatively impacted by the widespread adoption of educational technologies. The stress linked with teachers' use of digital technologies is an emerging area of research. To promote teachers' well-being through the design of CSCL tools, it is crucial to gain a deeper understanding of the stressful moments experienced by teachers when orchestrating collaborative learning activities facilitated by technology. Following a mixed method approach, this paper shed light on the triggers of teachers' perceived stressful moments when using a CSCL tool in F2F and online classes. Teachers reported feeling less stress during online sessions. However, more stress-related triggers and orchestrated actions were discovered during F2F sessions. It was found that technological difficulties, students' behavior, and time constraints all contributed to the highlighted stressful moments. In addition, the dashboard interventions were found more related to the stressful moments than other actions such as teacher-class interaction. This work provides an initial understanding of what makes teachers stressed when orchestrating CSCL activities from their perceptions. Collecting objective data about stress and orchestration load is needed to assert the findings of this work.

Introduction

In the field of computer-supported collaborative learning (CSCL), the notion of teacher orchestration has been used by several scholars to describe the way in which a teacher regulates different classroom activities, learning processes, and numerous of teaching actions in real-time (Dillenbourg et al., 2011; Dillenbourg & Jermann, 2010a; Dillenbourg et al., 2010b). Dillenbourg and Fischer (2010b) used the term orchestration to refer to "cognitive, pedagogical, and practical dimensions of a distributed CSCL environment". Teacher orchestration in this context refers to three aspects of a distributed CSCL environment: cognitive (e.g., managing individual, small-group, and class wide interactions); pedagogical (e.g., real-time adaptation of intended activities to classroom demands); and technology (e.g., management of the transactions between software components) (Dillenbourg et al., 2010b). The use of learning analytics (LA) tools such as dashboards may support teachers in monitoring and fostering the types of interactions between students that are favorable for learning (Van Leeuwen et al., 2014; Alavi & Dillenbourg, 2012; Dimitriadis, 2012). However, introducing teacher supporting tools as additional technology (e.g., dashboards) may affect the overall teacher's orchestration load resulting from facilitating and controlling collaborative learning.

Teaching itself, without considering the involvement of any technology, is already described by various researchers as a "stressful occupation" (Al-Fudail & Mellar, 2008). Adding technology to the equation of teaching, stress has been long associated with the use of technology in the workplace as well (Brod, 1984; Weil & Rosen, 1997). Stress in the workplace refers to an individual's reaction when confronted with a threatening scenario at work, which can be caused by a variety of circumstances that are aggravated by the use of new technologies (Fernández-Batanero et al, 2021). Further research (Raitoharju, 2005) on technology-induced stress defines six factors that can be a potential cause for technostress in the workplace: 1) the changes that may arise with the implementation of technology in the workplace, 2) a factor of pressure for an enhanced performance, 3) excessive information overload, 4) technology-induced anxiety due to the evolving nature of the former, 5) training of technical skills on a constant basis and 6) reduced social support due to the limitations of the virtual working space.

Studies on educational technologies focus mainly on improving student learning, while research on how teachers have been impacted by the emergence of technology in education is limited (Fernández-Batanero et al, 2021). The use of technology in learning and teaching processes may have negative impacts on teachers' well-being, since it could lead to shifts in their teaching methods or pressure to gain technological skills, resulting in physical, social, and psychological issues (Amarilla & Vargas, 2009). A growing subject of study is the stress associated with the teachers' use of digital technologies. Such stress can emerge due to a number of factors e.g., lack of training in use of technology, teachers' aversion to using technology in everyday teaching and learning situations, design issues related to teacher supporting tools (Fernández-Batanero et al, 2021; Toto, Limone, 2021).

In this paper, we explore the triggers of teacher perceived stressful moments when using a web based CSCL tool that enables teachers to implement Pyramid pattern-based learning activities (Authors, 2018). In addition, the orchestration actions that can be related to the identified triggers are explored. Thus, the research questions that are tackled in this paper are:

- What are the triggers of teacher perceived stressful moments when orchestrating collaborative learning with technology?
- What orchestration actions can be related with teacher perceived stressful moments when orchestrating collaborative learning with technology?

Background

Individuals' feelings and thoughts regarding the level of stress they are experiencing presently or over time are referred to as perceived stress (Lee & Jeong, 2019). It focuses on feelings about unpredictability and loss of control, with these frustrations causing changes in one's life as well as one's confidence in their capability to deal with challenging situations (Phillips, 2013). The term *Technostress* has been increasingly used due to a lack of adaptation to technological environments (Lee & Jeong, 2019). Technostress refers to a condition caused by an individual's inability to adapt to new technology use, which varies according to age, prior techno experiences, workload, and workplace environment, and ultimately affects people's performance (Brod, 2012).

In the field of education, several studies on technostress have covered students' use of technology in learning processes (Wang & Tan, 2020; Upadhyaya & Vrinda 2021), and the area that is more related to this paper, teacher technostress (Dong et al, ,2020; Li & Wang, 2020; Estrada-Muñoz et al, 2020). Initial research on teacher technostress attributed it to the introduction of technology into the classroom as well as a lack of adaptation to the technological environment (Al-Fudail & Mellar, 2008). More recent research has emphasized such a relation and extended to identify influences of technostress on teachers' psychological well-being (Efilti & Çoklar, 2019) and on their job satisfaction and technology-mediated performance in collaborative learning environments (Jena, 2015; Li & Wang, 2020).

Due to the dynamic nature of the collaborative classroom, teachers are generally under pressure to orchestrate the activity and have to continuously decide which group receives their attention at any given moment (Greiffenhagen 2012). The orchestration load resulting from facilitating CSCL activities remains understudied. In this study, the term orchestration is used to refer to the run-time coordination of CSCL activities, although this is not the only aspect of CSCL orchestration (Roschelle et al, 2013). According to Prieto, Sharma, Wen & Dillenbourg (2015), CSCL orchestration load can be broken down into two categories: a) the physical and logistical load (such as walking around the classroom and interacting with students); and b) the cognitive load of assessing what is happening in the classroom, weighing different actions, and deciding about how to better help the ongoing CSCL process (p.213). After observing teachers' orchestration actions in classroom situations, in our previous work have deconstructed orchestration load into three different facets namely: situation evaluation, goal formation and action taking (authors, 2021). Previous studies have also provided evidence that orchestration load can be estimated by triangulating multimodal data (observations, log data, physiological data) with teachers' subjective perceptions collected using questionnaires (Prieto et al., 2015; Authors. 2022).

Methods

Study design

The web-based tool used in this study provides an activity authoring space and a teacher-facing dashboard for the teachers and an activity enactment space for students. The teacher-facing dashboard provides a real-time overview of collaboration in addition to different controls, e.g., activity pause-resume, increasing time, and an alerting mechanism that informs critical moments of collaboration to the teachers to support their orchestration actions. Students can use their mobile phones, tablets, or laptops to join the activity. The activity flow is as follows: First students are required to provide an individual answer to a given task. Then they join in small groups and later in larger groups to discuss and improve individual answers and to reach a consensus at the end of the activity.

This study was designed to collect post-activity data from teachers about how they rate their stress level when orchestrating a CSCL activity, and whether they experienced particularly stressful moments, explaining the triggers of those if any exists. Thus, teachers were asked to complete a short questionnaire after orchestrating a technology-facilitated CSCL activity. Data was collected from five university instructors (three males and two females) who used the tool for orchestrating collaborative learning activities between Fall 2021 and Fall 2022.

Three of the participants have had three years of experience in using the tool, while two had been using the tool for one to two years.

Procedure

Data was collected from the teachers during 36 collaborative learning sessions. Due to the lasting consequences of Covid, ten of these sessions occurred during online classes. A four-item mixed-method questionnaire was designed to capture teachers' perception of the activity and the stressful moments. The first item asks the participants to rate their perception of the stress they experienced throughout the entire class from 1 to 10. Then they were asked to answer a Yes/No question whether there were any particularly stressful moments during the activity. In the case of a Yes answer, they were asked to describe that stressful moment in detail identifying its trigger and rate the level of the identified stressful moment from 1 to 10.

Data Analysis

For the quantitative data, means and standard deviations of the participants' rating of their overall and moment-related perceived stress during the activity in F2F and online sessions were calculated.

Then the qualitative responses provided by 60% of the participants about particular stressful moments were analyzed through qualitative content analysis (Hsieh & Shannon, 2005). This analysis was conducted to identify the triggers of perceived stressful moments and the orchestration actions that could occur concurrently with the perceived stressful moment. Qualitative content analysis is an approach for the subjective interpretation of textual data using the systematic categorization process of coding and identifying themes or patterns (Hsieh & Shannon, 2005). For the triggers, the text was firstly analyzed to identify patterns and suggest main categories of the triggers, then breaking each category to more specific triggers. For the orchestration actions, we adapted the codes in Table 1, which were found consistent with the CSCL activities being orchestrated in this study (Authors, 2021). If any other orchestration actions were mentioned in the responses, they will be coded and included as well.

Table 1
Codes defined to describe teacher orchestration actions when using the tool (Authors, 2021)

Codes	Actions
Teacher-individual interaction	The teacher replies to questions raised by individual students.
Teacher-class interaction	Interactions between teachers and the whole class (for example, the teacher requesting information from the class, debriefing the final responses, providing instructions to the students on how to use the tool, and completing the given activity).
Announcements to class	The teacher gives announcements to the students (i.e., time remaining for the activity and phase transitions of the script).
Check responses tab	This code contains the two actions (i.e., the teacher is checking individual student devices (e.g., mobile or desktop screens) as well as the task projection).
Check participation tab	This code describes actions of the teacher in the dashboard (i.e., checking information related to satisfactory and unsatisfactory voting participation of groups, opening a group box, and scrolling through the chat messages posted by the students and the new option formulated).
Dashboard interventions	This code describes actions of the teacher in the dashboard (i.e., checking information related to satisfactory and unsatisfactory voting participation of groups, opening a group box, and scrolling through the chat messages posted by the students and the new option formulated).

Results

As indicated in Table 2 teachers' average perceived stress in F2F sessions (M=5.96; SD=1.97) is higher than stress perceived in online sessions (M=3.3; SD=1.73).

Regarding the question asking whether the participants experienced particular stressful moments or not, the participants in 60% of the sessions (20 out of 36 sessions) answered with Yes and provided detailed answers that were considered for later analysis. 14 of these sessions were F2F and six were online.

Table 2

Mean and standard deviation of the overall perception of the stress out of 10 in F2F and Online sessions

Evaluate your perception of the stress you experienced throughout the entire class from 1 to 10 (not necessarily related to the cognitive load)		
	Mean	**SD**
F2F sessions (n=26)	5.96	1.97
Online sessions (n=10)	3.30	1.73
All sessions (n=36)	5.22	2.25

Following the qualitative content analysis approach, the content of the participants' textual responses was grouped into concepts and themes. In the first cycle of analysis, three main themes were identified as triggers of teacher-perceived stressful moments during orchestrating CSCL activities namely *Technological difficulties*, *Actions by students* and *Time-related issues*. An in-depth analysis was conducted to break down the aforementioned themes into more specific triggers, resulting in eight triggers. The *Technological difficulties* category included four triggers which are Dashboard Problems, Access Problems, Lack of prior knowledge about the tool, and Setting. *Actions by students* category included three triggers namely Noises from the students, Chat Messages and Answers. Last category is *Time-related issues* which have one trigger Shortage of time. A total of 30 stressful moments were identified, 16 of which were technological difficulties, eight of which were actions by students and six of which were time-related issues (Figure 1).

Figure 1

Categories of triggers of teacher-perceived stressful moments

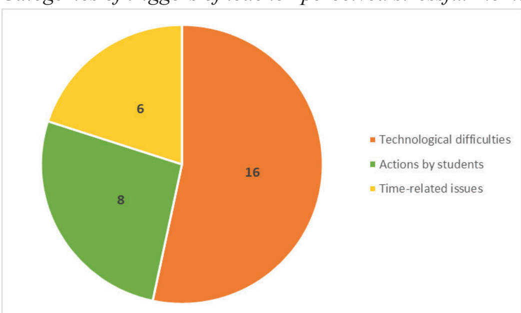


Table 3 provides details about the trigger category of the teacher-perceived stressful moments, the number of the stressful moments, per category, per trigger and per learning setting, in addition to examples of the teachers' responses and the orchestration actions related to the identified stressful moment. The participants identified 30 stressful moments overall. First, 16 stressful moments (53%) were caused by *Technological difficulties*, eight moments of which were brought up by access problems, while four moments were triggered by problems with the dashboard. Other three technological stressful moments were triggered by issues related to setting up the environment and one by the lack of prior knowledge about the tool. Second, *Actions by students* caused eight stressful moments (27%). Two of them were triggered by the noise students made during the activity, three by their chat messages, and four resulting from their answers. Third, *Time-related issues* caused six stressful moments (20%) due to time shortage in some of the activity phases (Figure 2).

In the F2F sessions, among 21 stressful moments that happened within 14 sessions, 12 moments were triggered by technological difficulties, seven by students' actions and two by shortage of time. On the other hand, among nine stressful moments that happened within six online sessions, four were triggered by technological difficulties, one by students' actions and four by shortage of time.

Regarding the orchestration actions that coincided with stressful moments, four codes of actions were identified from the analysis of the teachers' responses. Three of these orchestration actions are mentioned in the previous code scheme explained in Table 1, which are *Check responses tab, Check participation tab, Dashboard interventions* and *Teacher-class interaction*. In addition, we came up with a new code which is *Activity Configuration*. This code describes teachers' actions that are related to publishing the activity to the students.

A total of 26 orchestration actions were found associated with the identified stressful moments. There were eleven actions of Dashboard Intervention, eight of Activity Configuration, four of Check responses tab, two of Check participation tab and one of teacher-class interaction.

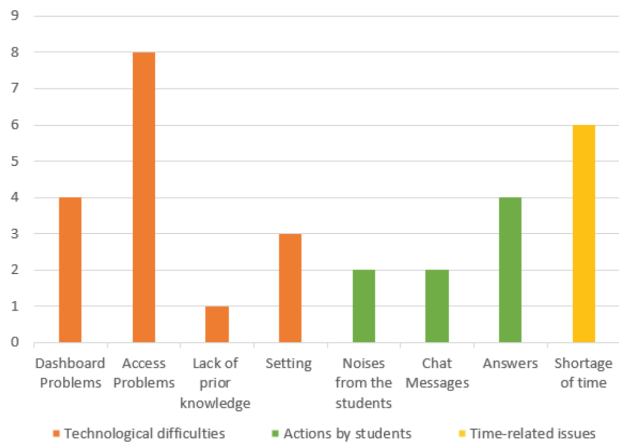
Table 3
Details about the triggers of the participants' perceived stressful moments

Trigger category	No. stressful moments	Triggers	No. moments per triggers and settings		Samples of participants' responses	Related orchestration actions
			F2F (n=14 sessions)	online (n=6 sessions)		
Technological difficulties	16	Dashboard Problems	4 (19%)	0 (0%)	- *"I pressed twice "Next phase" skipped the phase of improvement"* - *"I had issues making the "next step" control work"*	Dashboard Intervention
		Access Problems	5 (23%)	3 (33.3%)	- *"I informed wrongly the students about the activity URL"* - *"Students did not login correctly"*	Activity Configuration
		Lack of prior knowledge about the tool	1 (4.76%)	0 (0%)	- *"At the beginning it was not all clear to me"*	—
		Setting	2 (9.52%)	1 (11.11%)	- *"the laptop was running out of batteries and I needed to plug it"* - *"I needed to restart my browser"*	—
Actions by students	8	Noises from the students	2 (9.52%)	0 (0%)	- *"When students ended any phase in the Pyramid they started to talk, and the class started to be clearly noisy. Those moments/noise were alerting me that I needed to take an action: i.e. asking all of them to finish, and pressing "next phase" in the dashboard even if there were time left"*	Dashboard Intervention & Teacher-class interaction

		Chat Messages	2 (9.52%)	0 (0%)	- *"Some students wrote inappropriate and vulgar phrases in the chat, and the chat was not used for the purpose it should be"* - *" People were using the chat in an unserious and even rude way"*	Check participation tab
		Answers	3 (14.28%)	1 (11.11%)	- *"when some students still do not provide their answer when the time is finishing"* - *"When students told me that they could not continue editing their improved answer"*	Check responses tab
Time-related issues	6	Shortage of time	2 (9.52%)	4 (44.44%)	- *"In the submission phase I notice students were needing extra time just about when the time was finishing"* - *"The class time was running out, and I needed to reduce time in the activity"*	Dashboard Intervention
Total	30		21	9		

Figure 2

Triggers of teacher-perceived stressful moments



The mean of teachers' evaluation of how stressful they felt from 1 to 10 during stressful moments triggered by technological difficulties is 7.19 (SD= 1.24), during stressful moments triggered by students' actions is 7.0 (SD= 1.58), and during stressful moments triggered by time-related issues is 5.67 (SD= 1.37) (Table 4).

Table 4

Mean and standard deviation of the Stressful-moments perception out of 10 based on the trigger category

How stressed did you feel at the moment?

Trigger category	Mean	SD
Technological difficulties (n=16)	7.19	1.24
Actions by students (n=8)	7.00	1.58
Time-related issues (n=6)	5.67	1.37

Discussion

Understanding the teachers' stressful moments that contribute to the orchestration load in CSCL settings is important not only to design and develop CSCL tools but also to improve teachers' well-being. Following a mixed method approach in this paper, we shed light on teachers' perceived stress in F2F and online settings.

Overall, when considering the learning context, teachers reported their perceived stress is higher in F2F settings when compared to online settings. In order to understand why this is the case we conducted a detailed analysis by deconstructing each trigger (e.g., technology, aspects related to students and time). For instance, when considering the technological difficulties in both learning settings, our detailed analysis showed that in the F2F setting teachers faced a high number of technical problems arising from both CSCL tool and other extrinsic factors. For instance, regarding the CSCL tool, teachers' highlights faced a high number of dashboard problems which was reported as zero in the online setting. This is interesting because the same dashboard was used in both settings. We interpret that in the F2F setting teachers' not only pay attention to interpret information in the dashboard, rather they visit students' groups, talk to students etc. which deviate their attention from what is presented in the dashboard. Dividing teachers' attention across physical and digital space could have caused more stress for the teachers in the F2F setting.

When considering the trigger *"actions by students",* noise in the F2F setting was reported high when compared to online settings for obvious reasons. Off-task messages and answers were prominent in the F2F settings which added to the stress of the teacher as well. This hints that the nature/dynamics of the classroom could trigger off-task behavior among students during collaboration when compared to online settings which eventually contribute to increased teachers' workload that could result in stress. In addition, this finding indicates that the CSCL tool requires further improvements to facilitate fruitful collaboration among students in classroom settings and the tools' current design is more suitable to be used in the online settings.

Finally, the *"time related issues"* were common in both F2F and Online settings. This is a known issue in scripted scenarios in which collaboration is structured across a number of phases. In Pyramid scripts, determining the optimal number of phases required to reach a consensus and the adequate allocation of timing for the phases involves real-time decision making on the side of the teachers' considering both social and epistemic aspects of the learning situation that adds to their workload.

Conclusion and future work

The use of technology in the field of education adds a burden of stress to what has already been known as stressful processes, i.e., teaching and learning. This paper concerns the level to which teachers perceive their stress level when orchestrating CSCL activities, and explores the triggers and orchestration actions by which they experience particular stressful moments. While the overall teacher-perceived stress was found to be lower in online sessions, more triggers and orchestration actions related to stress were identified in F2F sessions. The triggers of teacher-perceived stressful moments were divided into three categories: technological difficulties, actions by students and time-related issues. About half of the discovered stressful moments were triggered by technological difficulties, while the dashboard intervention was the most related orchestration action to these moments.

The future direction of this work involves collecting data about teachers' stress and orchestration load beyond their subjective perceptions. Objective data is needed to further understand how orchestrating collaborative learning with technology can impact teachers' stress. For example, more data about orchestration actions is being collected from different sources such as video and dashboard recordings during CSCL sessions. In addition, physiological data (e.g., heart rate, temperature and electrodermal activity) is being collected from the same sessions to objectively estimate teachers' stress.

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Appendix A- HOW ARE LEARNING ANALYTICS CONSIDERING THE SOCIETAL VALUES OF FAIRNESS, ACCOUNTABILITY, TRANSPARENCY AND HUMAN WELL-BEING? A LITERATURE REVIEW

The content of this section is published in the proceedings of the Learning Analytics Summer Institute 2020 (LASI 2020)

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How are Learning Analytics Considering the Societal Values of Fairness, Accountability, Transparency and Human Well-being? -- A Literature Review

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Abstract. The scientific community is currently engaged in global efforts towards a movement that promotes positive human values in the ways we formulate and apply Artificial Intelligence (AI) solutions. As the use of intelligent algorithms and analytics are becoming more involved in how decisions are made in public and private life, the societal values of Fairness, Accountability and Transparency (FAT) and the multidimensional value of human Well-being are being discussed in the context of addressing potential negative and positive impacts of AI. This research paper reviews these four values and their implications in algorithms and investigates their empirical existence in the interdisciplinary field of Learning Analytics (LA). We present and highlight results of a literature review that was conducted across all the editions of the Learning Analytics & Knowledge (LAK) ACM conference proceedings. The findings provide different insights on how these societal and human values are being considered in LA research, tools, applications and ethical frameworks.

Keywords: Learning Analytics, Fairness, Transparency, Accountability, Wellbeing/ Well-being

1 Introduction

The interdisciplinary field of Learning Analytics (LA) borrows methods from Artificial Intelligence (AI) and goes together with several related areas of research in Educational Technology to understand and enhance learning. Certainly, Education is one domain where AI is having an increasingly relevant role and impact. According to the latest Innovating Pedagogy report [36], "AI-powered learning systems are increasingly being deployed in schools, colleges and universities, as well as in corporate training around the world". The emergence of the LA field has emphasized this trend and raised discussion about the possible positive and negative futures that can be envisaged considering the AI potential [27].

Although AI systems can bring benefits, they also present inherent risks, such as biases, reduction of human agency due to lack of transparency, decrease of accountability, etc. Therefore, societal initiatives (e.g. policy makers) and the AI scientific community are currently engaged in global efforts towards a movement that promotes positive human values in the ways we formulate and apply AI solutions. As the use of intelligent algorithms and analytics are becoming more involved in how decisions are made in public and private life, societal values of Fairness, Accountability and Transparency (FAT) are being discussed in AI research to address potential negative and positive impacts of AI. In addition, there are demands and efforts for considering AI impacts on all aspects of human wellbeing. The IEEE Global Initiative on Ethics of Autonomous and Intelligent Systems [71] recognizes in a recent report that prioritizing ethical and responsible AI has become a widespread goal for society, and the design of intelligent systems should directly address important issues of transparency, accountability, algorithmic bias, and value systems.

This research paper reviews these four values and their implications in algorithms and investigates their presence in the field of Learning Analytics (LA). First, we introduce the main concepts this paper revolves around, which are Learning Analytics, and the four values of FAT and Wellbeing. Then we analyze and highlight results of a literature review that was conducted across all editions of the Learning Analytics & Knowledge (LAK) ACM conference proceedings. The findings provide different insights on how these societal and human values are being considered in various LA tools, applications and ethical frameworks.

2 Research context

The research context of this paper is framed around a) data involvements in Education in the form of Learning Analytics that include, but are not limited to, AI methods and techniques, b) the problem of algorithmic bias as an active example of potential harmful impacts of using advanced data-driven algorithms, followed by societal concepts of fairness, accountability, and transparency, from the perspective of their relevance to preventing bias and ensuring positive AI impacts, and c) the notion of wellbeing as a multidimensional value, viewed from both perspectives of its theoretical background and the global efforts of promoting positive wellbeing impacts out of intelligent or autonomous systems (A/IS).

2.1 Data in Education

As people and devices are increasingly connected online, society is generating digital data traces at an extraordinary rate [6]. The term "Big Data" is used to reflect that a quantitative shift of this magnitude is in fact a qualitative shift demanding new ways of thinking, and new kinds of human and technical infrastructure [74]. Like many other sectors, Education has been affected by what commonly known as data revolution. Collecting reliable performance data for the purpose of tracking learning progress is being considered an essential feature for improved educational systems.

Learning Analytics. Big and small data approaches are present in Education in the form of Learning Analytics (LA). 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 [42]. By merging data techniques and analytics into learning technologies, data-driven tools and algorithms (e.g. analytics dashboards, recommender systems, intelligent tutoring systems ITS, etc.) are being designed and developed for understanding and enhancing learning. Arguably, the concerns of LA applications are driven by not only finding ways to enhance learning, but also by validating the complex processes used in this direction and evaluating their wider impacts.

2.2 Bias in Data Analytics

In the case of data collection and analysis, bias is always a major threat. To be biased means to be prejudiced for or against individuals or groups in ways considered unfair. Bias in data analytics can occur because the data collected are biased, or the humans who collected them are biased. The way people collect data can have significant influence on results that they obtain by analyzing the data [51]. Whereas cognitive socially-driven bias is an example of the human bias that can affect processes of collecting and analyzing data, the matter of data selection and generalizability is a typical example of how a data set can be biased. In addition, when software and AI methods are involved in data analytics, they may reproduce different forms of bias and impact a large scale of stakeholders: "algorithmic decision procedures can reproduce existing patterns of discrimination, inherit the prejudice of prior decision makers, or simply reflect the widespread biases that persist in society" [12].

Algorithmic Bias. Algorithms are widely defined as sequences of problem-solving operations conducted based on sets of rules and instructions to lead to predictable or desirable outcomes. The term *algorithm* in the context of this paper refers to the advanced computational algorithms that have capabilities from AI and machine learning, allowing them to autonomously make decisions based on statistical models or decision rules [39]. Even by this meaning, the limits of the term algorithm are determined by social engagements rather than by technological or material constraints [21]. Algorithmic bias can occur when algorithms reflect the implicit values of people who are involved in training the algorithm. Ways that people may be affected by algorithmic bias include being consciously and unconsciously subjects for forms of mistreatment (e.g. discriminatory, unfairness), and making different types of decisions depending on biased algorithmic outcomes.

2.3 Fairness, Accountability and Transparency (FAT)

As the use of algorithms and analytics are increasing and becoming more involved in multiple decision-making processes, social topics such as fairness, transparency, and accountability (FAT) are receiving more attention in research from the perspective of their relevance to preventing bias, and ensuring more ethical algorithmic practices. Regardless issues of data agency in the deployment of algorithms and analytics, new questions started to rise in the direction of shaping the ethical framework of decision-making algorithms. The ethical concerns these questions discuss go beyond the actual work of algorithms, mostly focus on the design and development phases of training an algorithm: How can fair algorithms be designed and developed? [65], how can we develop algorithms that are more transparent and accountable? [39], and how can we produce machine-learning algorithms that autonomously avoid discriminating against users and automatically provide transparency? [14].

Algorithmic Fairness. Oxford dictionary defines fairness as the "impartial and just treatment or behavior without favoritism or discrimination". As bias, by some means, is the lack of fairness and the excess of discriminatory, fairness can be understood as the lack of bias. Algorithmic fairness typically means that algorithmic decisions should not create discriminatory scenarios, but it is still a complicated topic because the definition of fairness is largely contextual and subjective [77]. With that in mind, some scholars and activists have been presenting multitude of technical definitions and solutions to substantially prevent algorithmic bias and maximize fairness and transparency.

Algorithmic Transparency. Transparency is generally considered a means to see the truth and motives behind actions [4]. In data-driven models and algorithms, transparency is understood as openness and communication of both the data being analyzed and the mechanisms underlying the models [40]. Some researchers considered algorithmic transparency as a way to prevent discrimination; assuming that when people understand how system works, they are more likely to use the system properly and trust the designers and developers [39]. Another applicable perspective of transparency in algorithms is about its ability to provide reasons for an autonomous decision (e.g. demonstrating reasons behind selections made by a recommender system). This view proposes that transparency in algorithms follows the sequence of logic: observation produces insights that create the knowledge required to govern and hold systems accountable [3]. Yet, full transparency can be significantly harmful. Therefore, transparency is just one approach toward the ethics and accountability of algorithms [20].

Algorithmic Accountability. Accountability refers to processes by which actors provide reasons to stakeholders for their actions and the actions of their organizations [63]. While people are responsible for reasoning their actions, algorithmic accountability concerns are driven by drawing the responsibility circle of algorithmic decisions. A critical question to define algorithmic accountability is: who is responsible for actions and decisions of an algorithm created by humans and able to make decisions without explicit human intervention? One answer on this suggests that accountability of algorithmic decisions must be derivable from the methods and data used by the algorithm in order to generate the decision [16]. Thus, accountability in algorithms and their application begins with the designers and developers of the system that relies on them [15]. Subsequently, questions that are more specific might be asked in order to hold algorithms accountable: What are the consequences of using an algorithm for individuals and societies? How influential are these consequences and how many people may be affected by? To what extent they are aware of the algorithmic mechanism that decides for them and drives their decisions and opportunities? What are the possibilities for algorithmic bias and discrimination to be occurring and leading to negative impact on the public? How this can be avoided from the early phases of designing and developing an algorithm? How can it be fixed if it happens during the implementation of the algorithm? What are the strategies of optimization and the techniques of intervention?

2.4 Well-being

For the purposes of aligning ethical considerations to intelligent systems' design, the term "well-being" refers to an evaluation of the general quality of life of an individual, and encompasses the full spectrum of personal, social, and environmental factors that enhance human life and on which human life depend [71]. Therefore, human wellbeing should not be perceived as a value of one dimension, and evaluations of wellbeing and the impacts of A/IS on wellbeing domains must be done with a consideration that human wellbeing is inseparably linked to the wellbeing of society, economies, and ecosystems.

Measuring Well-being. Wellbeing can be reliably measured [48 and 71]. Measuring wellbeing has become a target for several national and international institutions for the purpose of better understanding whether, where and how peoples' life is getting better (e.g. European Social Survey [24], OECD Better Life Index [48]). Subjective and objective indicators are being used by such institutions to measure wellbeing of individuals and societies. While subjective indicators are used to collect data about how people perceive the state of their wellbeing, objective indicators are used to gather observable data to measure wellbeing (e.g. incomes, graduation rates, etc.).

A question that has been recently asked is: what are the potential impacts, positive and negatives, on the various wellbeing dimensions that include but are not limited to: feelings, community, culture, education, economy, environment, human settlement, health, government, psychological wellbeing, satisfaction with life and work. [34].

Value Systems. Whatever their level of autonomy and their capacity to learn and make decisions, intelligent systems are required to incorporate societal and moral values into their technological developments at all phases of creating the system: analysis, design, construction, implementation and evaluation [17]. When creators of AI systems are not aware that indicators of well-being, including traditional metrics and all other personal and social indicators that improve quality of life, can provide guidance for their work, they also miss innovation that can boost well-being and societal value. A representative illustration of this concept is autonomous vehicles. The discussion is commonly centered in how they may save lives, but less is argued about their potential to reduce greenhouse gas emissions or to increase work-life balance or the quality of time. In education, for example, technology-enhanced learning implies that the presence of information and communication technologies in education has to be in a framework distributed for educational value creation at all levels. If we only use metrics of learning performance when designing and developing educational tools and systems, we may lose other relevant well-being facets such as effects in socio-emotional aspects, self-regulation, workload of teachers and learners, the inclusion dimension, etc.

3 LAK Literature Review

In this literature review, we investigated empirical existence of the four values of FAT and Wellbeing in LA research. The search was conducted across all the ten editions of Learning Analytics & Knowledge (LAK) conference proceedings from 2011 to 2020.

3.1 Method

This review is limited to LAK conference proceedings, as they, to a certain extent, reflect the work and results related to LA community. The search aimed to answer the following questions:

- To what extent are the concepts of FAT and Well-being existent in LAK papers?
- How do the LAK papers present and face these concepts?

A conventional search on the full texts of all LAK companion proceedings (from LAK11 to LAK20) was conducted by using the following keywords: *fairness, accountab*, transparen*,* and *wellbeing/ well-being.* The textual search covered every paper published in LAK proceedings according to tables of contents in ACM digital library. Since these conceptual keywords are relatively new to the field of LA, everything related to the topic was read, and judgments were made based on textual analysis aimed to identifying contexts of each keyword.

3.2 Quantitative Results

A total of 49 papers include one or more of the keywords used in the search. As shown in Table 1, there is a modest increase in the number of papers that tackle the four concepts across the years (from 2-5 in LAK11-15 to 7 in LAK16-20). The table shows the detail about the evolution across years in the use of each concept by LAK papers. In total, over 75% of the papers (37 out of 49) mention the concept of "transparency". 22% and 18% of the papers include the terms "accountability" and "fairness", respectively. And only 7 papers (14%) mention the term "well-being".

Table 1: Number of papers per each keyword across the ten LAK proceedings. Some papers include more than one keyword, so the horizontal total represents papers per year/proceedings

	Transparency	Accountability	Fairness	Well-being	Total
LAK11	2	-	-	-	**2**
LAK12	5	-	-	-	**5**
LAK13	3	-	-	-	**3**
LAK14	-	2	-	-	**2**
LAK15	2	1	1	-	**2**
LAK16	5	1	-	3	**7**
LAK17	7	2	2	-	**7**
LAK18	4	3	2	1	**7**
LAK19	5	1	3	1	**7**
LAK20	4	1	1	2	**7**
LAK All	**37**	**11**	**9**	**7**	**49**

3.3 FAT in LA Ethical Frameworks

In their endeavor to map ethical and legal basis informing LA practices, [54] cited the notions of transparency, accountability and fairness among other approaches aiming to solve complex data-centered ethical problems. In the range of these ethical approaches, legal frameworks attempt to make such complexities more palatable by reducing them to a series of principles. According to [33], the principles of fairness, accountability and transparency in existing international privacy frameworks can influence the whole design cycle of LA systems.

A review of eight existing LA policies for higher education was presented by [72] and discussed how these policies had tried to address notable challenges in the adoption of LA. The results of this review showed that all the eight policies had ensured that processes on student (and staff) data must be transparent. More insights on how data can be handled transparently were extracted from those eight policies and were interpreted by [72] as follows: 1) the methods used to collect data have to be disclosed to the subjects of the data collection; 2) the information about how data will be stored needs to be provided; 3) Users need to be notified about where their data has travelled in any integration process between multiple entities and informed about any changes made to the analytics process.

In the direction of establishing an ethical literacy for LA, [70] borrowed multiple frameworks from the field of technical communication to guide discussion on the ethics of LA "artifacts": data visualization, interactive dashboards, and LA methodology (gather, predict, act, measure, and refine). "When guided by such frameworks, an ethical literacy for LA will answer the question: Who generates these artifacts, how, and for what purpose, and are these artifacts produced and presented ethically?" [70].

Lack of accountability is a potential consequence of inaccurate or incomplete data that may be used in LA models. On that, the ethical literacy proposed by [70] described the need for understanding limitations of data in LA models as a limitation of accountability.

FAT in a Personal Code of Ethics. A draft personal code of ethics for LA practitioners was developed by [38] to consider whether such a code might determine the ethical responsibilities for individuals within the field of LA. This code considered the principles of fairness, accountability, and transparency as following:

Fairness. An ethical code of fairness for individuals involved in LA practices could be: “I will recognize that fairness and justice entitle all persons access to, and benefit from, the contributions of education and to equal quality in the processes, procedures and services being conducted through the use of data”.

Accountability. Although this personal code of ethics included parts that may define personal accountability, the authors concluded that there is currently no way in which individuals can be held accountable to any code. Given the scale and complexity of institutional LA systems, “it may be impossible to trace an individual’s actions without substantial, possibly unrealistically sophisticated, accounting systems being implemented”. Considering the need to distinguish between what is mandatory (professional obligation) and what is aspirational (moral guide) when applying personal ethical codes, [38] offered different contexts to explain to what degree can individuals be held accountable in LA practices. An example on what might be considered a mandatory code is: “I have a responsibility to act for the benefit of learners and to avoid any action that would harm the learner and their educational opportunity”. The following quote could be considered an aspirational personal code for individual accountability in LA: “I will ensure that I understand analytic processes (algorithms, statistics) that I employ. I will strive to promote accuracy, honesty and truthfulness in the science, teaching and practice of learning analytics” [38].

Transparency. The code also encouraged LA practitioners for more transparency: “I will ensure that data practices are transparent to those whose data I work with” [38]. Yet, being transparent regarding LA practices seems not to be an individual call.

3.4 Institutional Transparency

Educational institutions may need to set policies that reveal information about what data is collected, how they are used, etc., in ways that are technically and intellectually accessible to all relevant parties [31]. As [22] agreed, providers of analytical services have to demonstrate a transparent treatment for personal data. To make this possible, [56] suggested that addressing the practical implementations of being transparent regarding the collection and use of personal data could force companies and institutions to address practical policies and clarify their thinking. In a later work, the authors provided more insights on how higher education institutions should strive to be transparent. They suggested that institutions should allow students to: (1) know what data is collected, by whom, for what purposes, who will have access to this data downstream and how data might be combined with other datasets (and for what purposes); (2) be aware of the potential benefits that they may access in exchange for their data; (3) access to, and feedback on, the analyses that result from collection of their data, as this can support LA in its goal of not only providing institutions with a clearer understanding of how students learn, but also what students find useful [69].

3.5 Transparency and Data

Transparency was considered a problematic affair since the first efforts in both research and innovation within the LA field. While the issue of privacy was an alarm trigger to the ethics of LA, issues of transparency and openness about tracking learners' data have been a corner stone in such discussions. The main reason for this early attention to transparency is the nature of analytics as it derives from data. "It is not surprising that many outstanding concerns in LA center on data" [66], and it is often said that lack of transparency about data collection can cause unease among data subjects [22]. Therefor, "it should always be clear to a person that she is being tracked" [23].

3.6 Implications of Transparency in LA

Transparency for Understanding, Sense-making and Reflection. Investigations on the appropriate use of data in online education asked whether the transformation of data sets into measures and indicators is transparent and sensible [46]. Various LA applications (dashboards, recommenders, predictors) have adopted the concept of transparency as a method to support users' understanding and sense-making. According to [43], advances in visualization tools provide a great opportunity for researchers to develop visualizations that can improve transparency and therefore increase awareness and support reflection. An evaluation by [61] was conducted on a dashboard they had created to "empower students to reflect on their own activity, and that of their peers, in open learning environments". [60]. Open Learner Models (OLMs) were regarded by [37] as powerful means to enhance transparency, increase understandability and support reflection.

In a similar vein, [76] described how the use of analytics can be framed in a pedagogical model, where students viewed the analytics as a guideline for sense-making that can empower them to regulate their learning process. For LA prediction models, it was indicated that transparency related to the reasons why and how certain predictions are made is essential in order for teachers and students to understand how best to act upon the predictions [50]. Also, [26] showed how an LA recommendation could make more sense when the rationale behind it is transparent for the learner. According to a hypothesis by [47], "a more complex (i.e. black-box) model performs better, while a transparent model, despite given less accurate results, may be more valuable thanks to a higher degree of explainability". Recently, a study was conducted by [1] and aimed to investigate the impact of complementing Educational Recommender Systems (ERSs) with transparent and understandable OLMs that provide justification for their recommendations. The survey results indicated that complementing an ERS with an OLM has an overall positive impact on the students' engagement and enhances their acceptance of the system [1]. Additional work is needed to generalize such findings by comparing the effect between a transparent recommendation and a traditional black-box recommendation on students' motivation to follow the recommendation, and eventually, accept the tool [5, 49].

Transparency for Acceptance and Adoption. It has been noticeable by the LA research community that transparency is one effective way toward more acceptance for LA practices among users and stakeholders. An early heed of that was stated by [66] in his effort toward envisioning LA as a research and practice domain: "A proactive stance of transparency and recognition of potential learner and educator unease of analytics may be helpful in preventing backlash". This vision was supported by [10] who suggested that transparency can effectively benefit LA in overcoming challenges related to social acceptability. In addition, [73] found in a study aimed to understand LA privacy issues through students' own perception that transparency and communication are key levers for LA adoption. As also argued by [13], transparent modelling approaches such as decision trees allow teachers and learners to scrutinize analytics suggestions and reflect on them, which can lead to more agency of teachers and learners, therefore can lead to easier adoption.

Transparency to Build Trust. One of the earliest attempts to put transparency in LA innovation was by integrating a reputation system to a participatory learning platform for the goal of facilitating trust between users, by making actions and feedback transparent and allowing users to track their own learning and that of others [9]. Also, [41] found that transparency regarding what data is used, who data is shared with, and how algorithmic design choices are determined represent essential components for building trustworthy educational predictive models. Another proposition by [64] goes in line with discussions on the trustworthiness of AI, stating that providing educators with a level of control on an LA tool can ensure that the models are transparent and do not act as a black box for human interpretation.

Transparency and the Option to Opt-out. In several papers, Prinsloo and Slade presented the option to opt-out of the collection of certain types of data as a potential way to increase transparency [55, 56, 67 and 68]. The review of eight LA policies by [72] also indicated that multiple LA policies had taken such an option in consideration. Examples on these considerations, as summarized in this review included that users should be given the option to opt out of the data collection processes without any consequences, and that LA mechanisms must allow specific data to be withdrawn at any time. However, some other policies in this review stated that such an option is not available, because of the impossibility of delivering courses and supporting students without having their data stored in information systems [72].

Transparency to Support LA Co-design. Incorporating different resources of LA stakeholders and users (e.g. researchers, subject experts, students and teachers) into the design of analytical tools can improve usability and usefulness of these systems [18]. According to this argument, challenges of power-balance in such a 'co-creation strategy' for LA can be reduced through a clear distribution of roles and a high level of transparency among the different co-designers. On a practical level, [59] provided a student-centered design that applied deferent methods to engage students in the design, development and evaluation of a student facing LA dashboard. Transparency was underlined as a core contribution of this design, which "emphasis on fully utilizing the user-centered process, not just for initial requirements gathering, so that the design and development process of Student Facing LA systems is fully transparent, from the initial analysis stage all the way to final evaluation" .

Transparent LA Tools. Deferent perceptions have been proposed to describe when an LA tool is considered transparent. According to [62], an analytical tool supports transparency if users know what data about them is collected and who can see information about them. A stricter view considered an LA tool transparent when the users understand the whole process behind analytical outcomes [7].

Transparent LA Research. A research method was presented by [29] as an approach to conducting LA research. An important aspect of this method is the transparency on how a research work might contribute to a 'fully complete LA'. The method stated that researchers should "articulate the extent to which their work is constituent and contributes to an existing or future LA agenda, and/or it is aggregate and incorporates prior LA constituent research, in order to deliver a more complete LA" [29].

3.7 Institutional Accountability

Institutions and policy makers have to ask, "How can we use algorithmic decision-making in higher education to ensure, on the one hand, caring, appropriate, affordable and effective learning experiences, and on the other, ensure that we do so in a transparent, accountable and ethical way?" [58]. A paper by [33] showed how LA process requirements can be derived from an existing privacy framework (i.e. GDPR) by transforming legal requirements into systems requirements. This work provided a list of design requirements for LA including that "the institutions must be able to demonstrate that they have systems in place (policies and procedures) that uphold the protection of personal information and minimize risk of breaches". [33].

3.8 Algorithmic Accountability

Ways in which analytic devices become effective factors in learning has led to demands for greater algorithmic accountability, to ensure the pedagogic goals of analytic devices are transparent across all stakeholders [35]. As researchers should demand a rigorous level of accountability from LA devices, educators and students should also be encouraged to demand accountability to whatever level of detail they require [30]. LA devices shape or are shaped by learning contexts; and to make them eligible for learners and teachers they require careful analysis on the theory behind any given learning-target [35]. Thus, the implications of LA are not only critical for human inference and decision making, but also for algorithmic accountability [2].

3.9 Accountable Learning

The findings of a study by [32] showed that when the design of interactive features and analytics focus on contextual knowledge, it could foster learning of the conceptual knowledge that courses are typically accountable for. According to [44], "learning analytics has the potential to shape the curriculum, through enabling new kinds of learning practices that favor efficient and accountable ways of being over disciplinary knowledge-building or knower-building". For example, self-assessment can work as a tool to make students accountable for their learning [53].

3.10 Fair LA Outcomes

Fair Measurement. As LA often aims to measure learning, [45] discussed issues related to the fairness and validity of these measures. In her work toward establishing methodological foundations of measuring learning in LA, she stated that the different demographical and cultural backgrounds of participants can lead to biased responses to indicators used to measure learning. "This means that the measures may be confounded, causing unfairness for one group or another and certainly confusing any interpretations about what is being measured" [45].

Fair Instruction. Inaccurate data models about students can affect not only the learning measurement but the learning itself too. In the context of LA algorithms used to inform intelligent tutoring systems, [19] assumed that a fair outcome is when students from different demographical backgrounds reach the same level of knowledge after receiving instruction; no matter how long it took them to reach this level. On that, they proposed that adaptive educational algorithms, such as knowledge tracing, can contribute to preventing inequities between different groups of students by allowing them to go through the curricula in their own pace. However, such adaptive educational algorithms can still be unfair (e.g. favoring fast learners over slow learners) when they rely on inaccurate models of student learning [19].

Fair Prediction. Considering that predictive modelling has been one of the core research areas in the field of LA, and with such models are deployed in a variety of educational contexts, [28] presented a method for evaluating the fairness in predictive student models through "slicing analysis", an approach in which model performance is evaluated across different categories of the data. Although they argued that most of the prior work to define and measure predictive fairness are still insufficient for LA research, the researchers indicated that LA have to satisfy the existing legal concepts of fairness and should aspire even higher standers of fairness in the educational systems. While slicing analysis as an exploratory methodology can be used only to measures predictive fairness and not to correct it, they argued that measurement is a necessary condition for correcting any detected unfairness [28]. In this context, a point of view by [75] described LA dashboards as tools that offer a great promise to address bias-related challenges in prediction models, “as by visualizing the data used by predictive models end-users can potentially be made aware of underlying biases”.

3.11 LA to Support Well-being

Educational institutions have legal and moral obligations to demonstrate care for the wellbeing and growth of students, leading them to success in their education [22 and 57]. The support of student well-being was mentioned among the purposes that have encouraged students, in a study by [73], to welcome the university collecting and using of their data. In another study by [25] aimed to investigate perceptions of students and instructors of the potential benefits and risks of using LA, instructors also considered improving the overall learning experience and well-being of their students among the most important uses of LA. It is in the interests of education providers to devote LA for supporting students in developing social skills as well as domain knowledge [52]. Examples for such a potential include a paper by [11] aimed at exploring the potential of LA for improving accessibility of e-learning and supporting disabled learners. This work provided a comparative analysis of completion rates of disabled and non-disabled students in online courses and outlined how LA can identify accessibility challenges and disabled students’ needs [11].

3.12 Value-sensitive LA Design

A relevant paper by [8] introduced two cases of applying the Value Sensitive Design (a methodology from the field of Human–Computer Interaction) to support ethical considerations and system integrity in LA design. Both cases demonstrated that Value Sensitive Design could be an applicable approach for balancing a wide range of ethical and human values in the design and development of LA. Through a conceptual investigation of an LA tool developed to visualize online discussions in a learning platform, the researchers found that the following values supported by the LA tool can be in tension with other values: autonomy, utility, ease of information seeking, student success, accountability, engagement, usability, privacy, social wellbeing (in the sense of belonging and social inclusion), cognitive overload, pedagogical decisions, freedom from bias, fairness, self-image, and sense of community [8].

3.13 Summary of Qualitative Results

Table 2: Summary of the qualitative results from LAK literature review

Topics (As ordered in section 3)	**LAK Papers** (As numbered in the References)
FAT in LA Ethical Frameworks	[33], [54], [70], [72]
FAT in a Personal Code of Ethics	[38]
Institutional Transparency	[22], [31], [56], [69]
Transparency and Data	[22], [23], [66]
Implications of Transparency in LA:	
Transparency for Understanding, Sense-making, and Reflection	[1], [5], [26], [37], [43], [46], [47], [49], [50], [61], [76]
Transparency for Acceptance and Adoption	[10], [13], [66], [73]
Transparency to Build Trust	[9], [41], [64]
Transparency and the Option to Opt-out	[55], [56], [72]
Transparency to Support LA Co-Design	[18], [59]
Transparent LA Tools	[7], [62]
Transparent LA Research	[29]
Institutional Accountability	[33]
Algorithmic Accountability	[2], [30], [35]
Accountable Learning	[32], [44], [53]
Fair LA Outcomes:	
Fair Measurement	[45]
Fair Instruction	[19]
Fair Prediction	[28], [75]
LA to Support Well-being	[11], [22], [25], [52], [73]
Value-sensitive LA Design	[8]

4 Conclusions

The global efforts toward positive impacts of AI-powered systems on humans' well-being continue to establish societal guidelines for such systems to remain human-centric, serving humanity's values and ethical principles. Although the LA community is increasingly concerned about ethics, the societal values framing the notion of Responsible AI have been approached only to a limited extent and are scattered across LA research. Most cases focus on transparency. Yet, truly research around positive impacts of LA should be addressed from a holistic perspective that goes beyond transparency and considers accountability and ways by which LA systems contribute to diverse dimensions of human well-being in and beyond the educational scenarios. To do so, there is a need for addressing metrics and techniques to help educational technology stakeholders in safeguarding human values and well-being when they design, develop, implement and evaluate LA tools and solutions.

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Appendix B- TEACHER'S ORCHESTRATION ACTIONS IN ONLINE AND IN-CLASS COMPUTER-SUPPORTED COLLABORATIVE LEARNING

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Exploring Teacher's Orchestration Actions in Online and In-Class Computer-Supported Collaborative Learning

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Abstract. Teacher orchestration of technology-enhanced learning has received increasing attention as a factor for enhancing students' learning gains. However, a limited number of studies have investigated the impact of learning settings on teachers' orchestration actions. In this paper, we considered two different settings of computer-supported collaborative learning (CSCL) activities, namely online and in-class, and studied their influence on teachers' orchestration actions. Data was collected from five sessions for each setting. The findings indicated that during the in-class sessions there were more teacher-individual interactions, announcements, checking participation/responses tabs, and dashboard interventions conducted by the teacher. In the online setting, however, more teacher-class interactions occurred when compared to the in-class setting. The implications of this study and its continuation are related to the consideration of the learning setting in the design, redesign, and evaluation processes of orchestration technologies.

Keywords: Computer-supported collaborative learning · Orchestration · Dashboards · Teacher support tools

1 Introduction

The term "orchestration" has been used in Education to describe the real-time management of multiple classroom activities, various learning processes and involving numerous teaching actions [1]. In technology-enhanced learning, orchestration technologies are the digital tools that support teachers in the orchestration of complex learning activities [2]. Such tools have been especially proposed to support teachers in orchestrating student collaboration across learning flows, in the sense of guiding, the managing and coordinating, activity sequences, group formation, resource distribution, etc. [3]. In alignment with the concept of orchestration technologies, the field of Computer-Supported Collaborative Learning (CSCL) studies the use digital tools to design and deploy collaborative learning activities [4]. In this context, teacher orchestration refers to three dimensions of a distributed CSCL environment: cognitive (e.g., regulating individual, small-group and

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class-wide interactions), pedagogical (e.g., real-time adaptation of the designed activities to the classroom needs), and technological (e.g., management of the transactions between software components) [5].

Orchestration technologies are being mostly designed for classroom, with the most salient part of the scenario occurring face-to-face [1]. Thus, the implementation of CSCL activities in fully online environments can be challenging for teachers and students at both levels, educationally and technologically. Several studies have discussed the difficulties the students face when performing online collaborative activities [e.g., 6, 7]. Major challenges include ineffective communication, conflict among group members, and negative behavior toward group work [6]. Less attention has been paid to understand how teachers' orchestration actions differ across different learning settings, e.g., in-class and online setting.

Therefore, in this paper we explore the teacher's orchestration actions in two settings namely in-class and online in the use of PyramidApp [8], a web-based tool that allows teachers to deploy Pyramid collaborative learning flow pattern based scripted collaborative learning activities. PyramidApp consists of an authoring space which facilitates activity authoring, activity enactment space for students and a teacher-facing dashboard that provides orchestration support, e.g., information about students' activity participation as well as functionalities to adapt the flow of script in real-time. The activity flow is as follows: First students require to provide an individual option to a given task. Then they join in small groups and later in larger groups to discuss and improve individual options and to reach a consensus at the end of the activity.

We analyzed data collected from a single teacher across ten sessions, five of which were online and five in-class. We used a mixed-methods approach to answer the following research question: *To what extent do the teacher orchestration actions differ in online sessions when compared to in-class sessions of computer-supported-collaborative-learning activities?*

We posit that the contribution of this study, as a work in progress, to the field of technology-enhanced learning would advance the examination of how different learning settings, i.e., online and in-class, influence teachers' orchestration actions which could also help us to explain better the orchestration load experienced by the teachers in future studies.

The rest of the paper is structured as follows. In Sect. 2, describes the provides methodology followed to answer the research question. In Sect. 3, presents study findings and lastly Sect. 4, discuss the results, limitations, and future work.

2 Method

2.1 Data Collection

A female teacher from a public university in Spain has participated in this study. She had over 17 years of teaching experience and had previous experience in authoring and orchestrating CSCL activities. The main criteria for selecting the participant were the existence of teaching experience, prior knowledge, and experience in using PyramidApp in both online and in-class settings. The teacher conducted ten Pyramid activities five of which were online and the other five were in-class sessions.

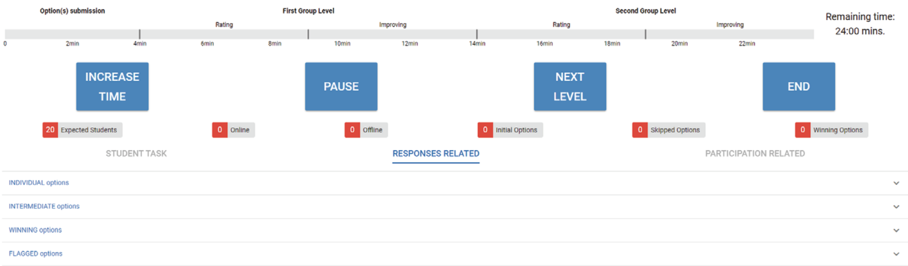

Fig. 1. Teacher-facing dashboard used by the teacher.

Data was collected through capturing audio data from each session, screen- recording the teacher-facing dashboard (see Fig. 1) and taking observation notes while the teacher was orchestrating the activity. Moreover, the log data that indicated the relevant details were extracted from the PyramidApp database (e.g., the number of students participated in the activity, duration of the task, the task given for each session and the actions taken by the teacher in the dashboard). The screen and audio recordings, the observations notes, and the log data were analyzed to explore how teacher's orchestration actions differ in two settings (i.e., Online and In-class) using PyramidApp tool.

The tasks for the five online sessions were the same as those for the five in-class. However, the design of each collaborative learning activity differed depending on the teacher's requirements for conducting CSCL activities in each session. Table 1 presents the tasks given by the teacher and the number of students who participated in each session. In addition, tasks A and B were conducted in an undergraduate class and tasks C and D were conducted in a master class. Task B was used in four sessions (i.e., Online1, In-class1, Online2 and In-class2), while each of the other three tasks were used in two sessions (i.e., Online1 and In-class1). Each activity lasted around 9 to 19 min.

Table 1. A Summary of Collaborative-Learning Activities Conducted".

Task given to students	Sessions by condition and number of students			
	Online1	Online2	In-class1	In-class2
Task A. Identify and explain three errors in the shown servlet, which aims to implement a change in its behavior depending on the web page from which it is linked to:	15	–	8	–
Task B. Analyze a scenario to identify non-functional requirements	15	16	8	11
Task C. Which factors should be considered when considering the implementation of learning analytics?	16	–	14	–
Task D. List differences between a LMS and MOOC platform	15	–	15	–

2.2 Coding Teacher's Orchestration Actions

To be able to answer the research question, we analyzed orchestration actions of the teacher across the ten sessions. Teacher's orchestration actions were coded following a coding scheme defined in [9]. This coding scheme includes six codes as follows: 1) *Teacher-individual interaction* 2) *Teacher class interaction* 3) *Announcements to class* 4) *Check responses tab* 5) *Check participation tab* and 6) *Dashboard interventions.* More details about the codes are presented in Table 2.

Table 2. Codes defined to describe teacher's actions.

Codes	Actions
Teacher-individual interaction	Teacher responds to specific questions asked by individual students
Teacher class interaction	Interactions between teachers and the whole class (i.e., teacher requests information from the class, debriefs the final answers, provides directions to the class about how to use the tool and perform the given task)
Announcements to class	Teacher makes announcements to the class (i.e., time remaining for the activity and phase transitions of the script)
Check responses tab	This code describes actions of the teacher in the dashboard (i.e., scrolling answers received from individual students and the highly rated answers at the group level)
Check participation tab	This code describes actions of the teacher in the dashboard (i.e., checking information related to satisfactory and unsatisfactory voting participation of groups, opening a group box, and scrolling the chat messages posted by the students and the new option formulated)
Dashboard interventions	Summarizes dashboard interventions by the teacher (i.e., use of Next Level, Increase Time, End and Pause buttons in the dashboard)

3 Findings

This section presents the results obtained after the analysis of ten sessions distributed to four collaborative learning tasks. We compare the number of teacher's actions in each task of both settings (i.e., Online and In-class). Figure 2 shows two graphs, one for the actions taken during the online sessions and one for the actions taken during the in-class sessions. Then we present and compare the aggregated actions for all the tasks in different settings. (Table 3).

As shown in Fig. 2, in all tasks there were differences in the *teacher-individual interaction.* The individual students interacted more with the teacher in the in-class sessions when compared to the online sessions. In tasks A and D, the teacher conducted more

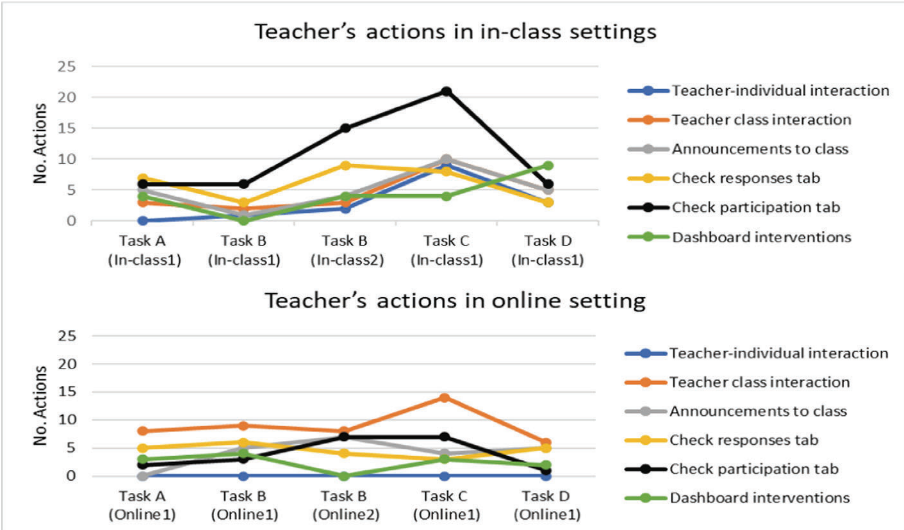

Fig. 2. Teacher's actions in both online and in-class settings.

class interactions in the online sessions. Moreover, actions from *announcements to class*, *check responses tab*, *check participation tab* and *dashboard interventions* occurred more in the in-class sessions than in the online. Task B was used in two different sessions. The first one (i.e., Online1 and In-class1), actions such as *teacher class interaction*, *announcements to class*, *check responses tab* and *dashboard interventions* occurred more in online sessions. However, *check participation tab* actions occur more in in-class sessions. The second session (i.e., Online2 and In-class2), the teachers conducted more *class interactions* and *checked the responses tab* in the online session. The number of announcements to the class were the same in the online and in-class sessions. In addition, the teacher conducted more *dashboard interventions* during in-class sessions when compared to the online sessions. In task C, the teacher interacted with the class and made more announcements in online sessions when compared to the in-class sessions, while actions from *check response/participation tabs* and *dashboard intervention* happened more in in-class sessions.

Table 3 shows the difference between aggregated actions of each code in the two settings. The findings show that during the in-class setting there were more *teacher-individual interactions, announcements, check responses tab*, *check participation tab* and *dashboard interventions*. In the online setting, however, the teachers conducted more class interactions and fewer individual interactions when compared to the in-class context (Table 3). It is also interesting that the teacher was not using less the monitoring features of the classroom in the In-class condition, but the contrary. Differences in the number of times that the teacher decided to check student participation are substantial.

Table 3. Teacher's actions in all online sessions and all in-class sessions.

Actions	Online	In-class
Teacher-individual interaction	0	15
Teacher class interaction	45	23
Announcements to class	21	25
Check responses tab	22	29
Check participation tab	21	49
Dashboard interventions	12	21
Total	121	162
Average	20	27

4 Discussion and Future Work

Teacher-individual interactions occurred less often in the online sessions, even though there were more participants in this setting (n = 77) than in the in-class sessions (n = 56). The lack of interactions with individual students might indicate less workload to the teacher. This might be due to a communication issue connected to the students' willingness to raise questions during online sessions, which is consistent with the literature suggesting that communication has shown to be the biggest challenge in online collaboration. [6]. Also, we assume that the number of *teacher-class interactions* in the online setting indicates the need for more explanations about how to use the facilitating CSCL tool when compared to the same interactions in the in-class setting. Most of the actions in this category (31 out of 45 in the online setting, and 20 out of 23 in the in-class) were technology-related, i.e., the teacher is giving directions to the students about the use of the facilitating tool. To further investigate such assumptions in the future, we are working on analyzing the students' performance during online and in-class sessions (e.g., the total number of students who completed the task in each session, quality of their outcomes).

The data collected for this study is limited due to the criteria of data collection, and the differences between learning designs across sessions. More data will be collected in the future from other teachers who taught the same course to enable for more in-depth analysis and generalizable findings.

The implications of this study and its continuation are related to the consideration of the learning environment in the design, redesign, and evaluation processes of orchestration technologies, and how they can impact the teacher orchestration load as well as the student learning and collaboration. This ongoing research would also further the investigation of how orchestration tools could facilitate teachers to regulated CSCL activities in different settings. It can be of interest to practitioners who teach in distance, online and hybrid settings and other stakeholders in the wider TEL field.

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Appendix C- RESPONSIBLE EDUCATIONAL TECHNOLOGY RESEARCH: FROM OPEN SCIENCE AND OPEN DATA TO ETHICS AND TRUSTWORTHY LEARNING ANALYTICS

The content of this section is a book chapter accepted for publication in: Raffaghelli, J., Sangrá, A., Data Cultures in Higher Education, Springer book series on Higher Education Dynamics.

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Responsible Educational Technology Research: From Open Science and Open Data to Ethics and Trustworthy Learning Analytics

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Abstract

This chapter unfolds some elements of responsible research in the educational technology field and provides examples about how these elements have been considered in initiatives by the Interactive and Distributed Technologies for Education (TIDE) research group at Universitat Pompeu Fabra in Barcelona. First, it focuses on Open Science, an ongoing movement that promotes on the one hand, transparent and frequent open-access updates of the research progress and the collected data; and on the other hand, reproducible, accurate and verifiable research, bringing benefits for the individual researchers, the research community and the society. Second, the chapter discusses ethics perspectives in educational technology research, relevant when collecting and sharing data and also in the design and development of technologies, especially when they are based on data analytics or artificial intelligence techniques. The latter aspects relate to the capacity of educational software systems to support human agency and preserve human wellbeing.

Keywords

Responsible Research and Innovation (RRI), open science, ethics, educational technologies, learning analytics

1. Introduction

The "scientific ethos" comprises the guiding norms, beliefs and ideas that provide the foundations on which science as a social institution operates. Merton provided in 1942 one of the first and most influential descriptions of the post-war contemporary scientific ethos, based on four norms, interrelated with each other: Universalism (conformance to previously accepted knowledge and evaluation subject to pre-established impersonal criteria), Communalism (a sense of common ownership of goods, in return to recognition and esteem), Disinterestedness (appearance to act under passion for knowledge, ensuring integrity), and Organised Skepticism (a detached community scrutiny of beliefs in terms of empirical and logical criteria). The "scientific ethos" provides shared foundations for those self-identified and recognised as part of the scientific community, as well as a source of legitimacy from the society to them. The perceived social credibility of the corresponding practices to these norms (such as certification and ruling organized through peer-review) have traditionally provided the scientific community with a great autonomy of functioning as a social institution, including the selection of research questions, the internal recognition mechanisms of individuals and organisations, the internal governance mechanisms and, even, how public funding was distributed. Openness was intimately linked to the concept of good science, in terms of the stimulation of discovery, its impact on society and the guarantee of systemic integrity. The openness of these practices was an implicit requirement to keep this legitimacy.

Although the Mertonian view has been evolving over time (with the contributions by Kuhn and Latour as examples of the most popular evolutions and controversies), it still represents an accepted tacit representation for the scientific community and its contract with society. But the pace and impact of the scientific and social transformations we have been experiencing in the last decades have, as a minimum, transformed the best practices associated with those beliefs, if not posing pressures to redefine them for the new and future contexts (Krishna, 2020).

Like any other aspect of society, information and communication technology (ICT) has impacted the way science is conducted, and generated new areas of research (such as educational technologies). It has also transformed how we communicate, share and access results (and even generated a new range of research products, such as research data and software). The globalization of the economy has greatly expanded the number of actors in the scientific community, both in terms of geography, but also with respect to the increase of the participation of private, profit-oriented research organizations (such as large multinationals, most relevantly in the ICT and biomedical sectors). The rise of democracy across the world, in connection with a massive increase in the access of education in several regions as a needed condition to participate in the "knowledge society", has promoted openness in new terms, such as citizen participation (such as the case of "crowd science", Franzoni & Sauermann, 2014) but also criticism (such as the rise of denialism and questioning in society, combined with the so-called "reproducibility crisis"), which is even questioning the role of science as the provider of general unquestionable knowledge. Finally, the acknowledgment of grand, global challenges (such as climate change, or the ongoing COVID19 pandemics), where science is perceived not only as a key driver to tackle them, but a relevant actor in policy-making, has fostered new roles for science which are based on different standards to those of academic science. As a result of this evolution, a "renaissance" of the discussions around the scientific ethos emerged. On the one hand, it resulted in a widening of the understanding of the concepts of universalism, communalism and disinterestedness, represented in Europe by the rise of the concept of Responsible Research and Innovation (RRI; EC, 2015).

RRI has been extensively used in recent years to describe an approach to governing science, including its processes and results, but also including an assessment of its implications and the societal expectations. RRI expands the traditional evolution of Open Science, often focused on technical organisation, with an extra emphasis on normative concerns and democratic deficits. RRI is built on multiple evolving pillars. The first relates to public engagement and considers the ways in which research can be shared with the public. The second has to do with gender and ranges from gender equality in research to the incorporation of the gender dimension in conducting research. The third is about promoting science education, with a strong emphasis in the inclusiveness of this education. Ethics is the fourth pillar and covers topics such as ethical research methods or professional ethics. Open science is a pillar including topics such as open access to research results - publications, data, software, etc -, open processes - such as open peer-review - or infrastructures - such as open science cloud. Other pillars have to do with governance, social justice, inclusion, and sustainability which, in addition to open science, aim at updating the scientific ethos and its associated best practices to the current and anticipated evolution of society, and the role of science and its community in it. The relevance of data to the RRI pillars is clear. Indeed, data practices are intrinsically connected with several of these pillars, with more emphasis in the cases of the ethics and open science pillars.

Research in education and in educational technologies is not an exception. Technologies are also increasingly transforming the practice of education in general, the type of research conducted on education, and the way it is conducted. All dimensions of RRI are of special relevance to it, as education is a complex human phenomenon, and is increasingly considered as a global common good (UNESCO, 2015). Researchers in this field are increasingly recognizing these challenges and adopting strategies towards what we could call "responsible educational technology research".

This chapter aims at contributing to this community effort by sharing practices and meta-research (Ioannidis, 2018) studies that align with elements of responsible research (Figure 1) in the educational technology field. The cases summarize examples about how these elements have been considered in initiatives by the Interactive and Distributed Technologies for Education research group at Universitat Pompeu Fabra in Barcelona (TIDE-UPF, www.upf.edu/web/tide).

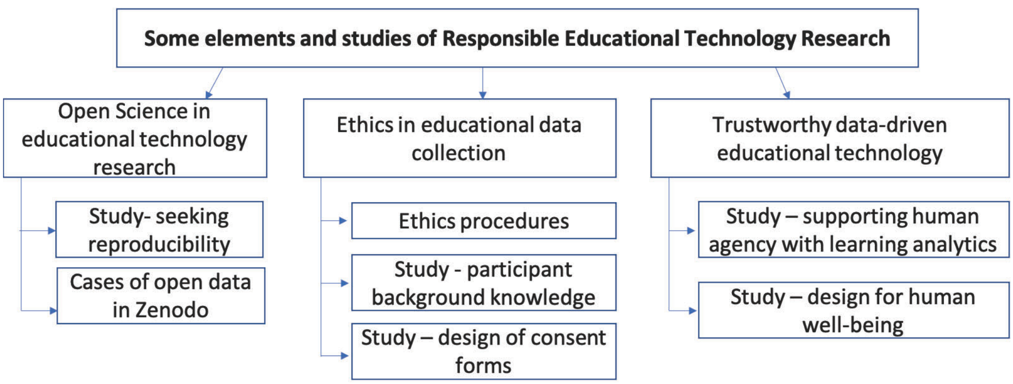

Figure 1. Elements of Responsible Educational Technology Research addressed in the chapter

The first element of responsible educational technology research tackled in the chapter is directly connected to the notion of Open Science, in particular with the reproducibility and open data facets. Like other fields, educational technology research suffers from a reproducibility crisis. There are even voices in the community alerting that educational research has been found to have lower replication rates than other academic fields and call for “conducting replications on important findings” as “essential to moving toward a more reliable and trustworthy understanding of educational environments” (Makel, 2014). There are several initiatives that aim to change closed and nontransparent approaches to research. van der Zee & Reich (2018) discuss that it is possible to engage in “Open Educational Science” by making more transparent and accessible each stage of the scientific cycle (research design, data collection, analysis, and publication) with open approaches to science, such as pre-registration, data sharing, transparent analyses, and open access publication. There are now several specialized Web platforms (e.g. Zenodo, Figshare, LearnSphere, GitHub) where researchers can share datasets and software used in studies so that other researchers can reproduce or extend the analysis. However, despite their relevance, these initiatives have not been broadly adopted (Raffaghelli & Manca, 2019).

The second and third responsible educational technology research elements discussed in this chapter are related to ethics in educational technology research. The second element deals with the perspective of ethical data collection. The presented perspective recognizes that standard ethics procedures in educational technology research already take into consideration key aspects but it also questions the relevance of the details in the implementation of those procedures, such as the previous knowledge of the participants and the articulation of consent forms. Finally, the third element tackles the perspective of the ethical design of data-driven educational technology interventions. This perspective also connects with responsible dimensions of social justice, inclusion and sustainability, mentioned above, and aligns with emerging discussions about desired ethical considerations in the design of trustworthy Artificial Intelligent (AI) systems. In the hope that AI and data-driven systems (including those used to support educational scenarios) should clearly prevent and minimize their risks while still exploiting their benefits (HLEG-AI, 2019), a focus on human-centered and well-being-driven design approaches offers a path for data-driven systems to respect human autonomy and the common good.

The following sections in the chapter elaborate on each of these responsible educational technology research elements with examples about how each of them have been considered or meta-researched.

2. Efforts towards Open Science in Educational Technology Research

Reproducibility and open data are key facets in the open science movement, which promotes on the one hand, transparent and frequent open-access updates of the research progress and the collected data; and on the other hand, reproducible, accurate and verifiable research, bringing benefits for the individual researchers, the research community and the society. This section presents two examples of efforts carried out by TIDE-UPF towards achieving these principles in educational technology research.

2.1 Seeking reproducibility

Multimodal Learning Analytics (MMLA) is a research domain within the educational technologies field that aims to better understand and measure learning processes by making use of data from an array of sources including "recorded video and audio, pen strokes, position tracking devices, biosensors" (Ochoa, Lang, & Siemens, 2017). Increasingly, educational technology researchers are exploring MMLA as there is a rising need to model across physical and digital worlds to gain a more holistic view of student learning and supporting technologies and techniques are becoming more accessible. However, the complexity and exploratory nature of MMLA can make it difficult to adhere to Open Science standards. Standards such as the Transparency and Openness Promotion (TOP) Guidelines call for greater transparency in relation to research designs, materials, data, and analysis to support reproducible research (Nosek et al., 2016). Thus, to explore challenges related to incorporating multimodal data on learning into research in a reproducible manner, a direct replication of a multimodal wordlist experiment on the forward effect of testing (Pastötter, Schicker, Niedernhuber & Bäuml, 2011) was conducted. The study made use of both behavioural and physiological data (electrophysiological measures of brain activity) but differed from the original study in that more accessible low-cost equipment and open-source software were used. Further, two rounds of the experiments were run with the second round focussed on increasing the power of the study and improving its reproducibility. A summary of the description of the study and its findings follows.

The replication study, *Seeking reproducibility: Assessing a multimodal study of the testing effect* (Beardsley, Hernández-Leo & Ramirez-Melendez, 2018), served two purposes. The first was to become more familiar with and contribute an empirical study related to retrieval learning also referred to as test-enhanced learning as it is an underutilized teaching and learning strategy (McDaniel & Fisher, 1991; Roediger & Karpicke, 2006). The second was to try to validate multimodal setup upon which future conceptual replications of the wordlist experiment and the testing effect could be conducted (e.g. such as replacing the wordlists with more authentic learning materials).

In the original study, Pastötter, Schicker, Niedernhuber and Bäuml (2011) found behavioural and physiological evidence that retrieval during learning facilitates the encoding of subsequent learning. Participants studied five distinct wordlists. The group that did a retrieval activity (free recall of words) rather than a restudy activity (reviewing the list of words) prior to learning the last wordlist was able to recall more words from the last wordlist. Moreover, alpha wave oscillations, as measured by an electroencephalogram (EEG), differed between the groups. The alpha power of the group performing the restudy activities increased across wordlists whereas the retrieval activity group did not show such an increase in alpha power. Increases in alpha power corresponded with poorer recall of words from the target wordlists. The original study was conducted in a laboratory setting and made use of costly equipment and proprietary software.

The replication study made use of a low-cost EEG (electroencephalogram) device, open-source software, and was conducted in a classroom setting. University students (n = 46) took part in the replication study that was conducted across two rounds. A low-cost Emotiv EPOC® was used to acquire electrophysiological data. PsychoPy (Peirce, 2009) was used to present the wordlists and collect behavioural data. OpenViBE was used to acquire and process the EEG signal (Renard et al., 2010). RStudio was used to perform the statistical analysis (RStudio Team, 2015). However, the replication attempt had participants study three rather than five distinct wordlists due to the limited battery life of the low-cost EEG device.

Behavioural results of the wordlist experiment were replicated but physiological results were not. The retrieval group (M = 6.32, SD = 1.84) performed significantly better than the restudy group (M = 2.33, SD = 1.40) in recalling words from the third and final wordlist ($p < .001$, d = 2.61). The electrophysiological results (i.e., changes in alpha power across wordlists) were not significantly different between the retrieval and restudy groups. However, rather than interpreting the results as not supporting the original study being replicated, the results are better interpreted as a failed attempt to validate our specific multimodal experimental setup. A number of problems were encountered in using the low-cost device which resulted in data from 13 participants being excluded from the analysis and suggesting that there may be additional concerns regarding the physiological data collected.

During the second round of the replication study, steps were taken to improve the reproducibility of the work being done. For example, preregistration of the study was completed for the second round of trials to restrict researcher degrees of freedom, in addition to null-hypothesis significance testing the results include effect size and confidence interval calculations to facilitates power calculations and meta-analyses (Lakens, 2013), and to provide greater transparency study data (Beardsley, Vujovic, & Sayis, 2017) and the software implementation of the experiment (Beardsley, 2017) was made publically available online in Zenodo.

2.2 Open data in Zenodo

Zenodo (https://zenodo.org) is an open repository that provides space to store and share research artefacts that may include datasets, software, publications, posters, presentations, audio/video and any other materials related to the scholarly process for free (European Organization For Nuclear Research and Ope-nAIRE, 2013). The repository was launched in 2013 and is operated by CERN. Zenodo allows anyone to register as a user and upload their research-related artifacts. It does not impose limits on the format of the upload, nor does it impose limits considering the status of the research data. However, the file size limit per record is limited to 50GB, which can be increased upon request. As indicated within the general policies of Zenodo, the uploaded content in Zenodo will be retained for the lifetime of the repository.

When uploading the content users require to provide metadata about the research artefacts, choose a license and access rights for the uploaded content. The available access rights options include open, embargoed, restricted, and closed access. Uploading research artefacts in Zenodo does not require a change in ownership or property rights transfers. Once the uploaded records are published in Zenodo, it automatically assigns a Digital Object Identifier (DOI) to every published record for citation purposes. After publishing the records, it is possible to update metadata at any time. Modifying existing records will resolve to a new version that is also assigned a new DOI. It is also possible to withdraw content from Zenodo. However, the withdrawal requires to be requested and fully justified by the original uploader.

Zenodo also allows to create communities and to associate research artefacts to certain communities of interest. The TIDE-UPF research group curates the “Educational Data Analytics” community, focused on data whose analytics can be used for research purposes (including, learning analytics, design analytics, teacher communities analytics). At present this community consists of 8 datasets, 2 software and 1 publication. In the following we provide details of two examples of shared data sets.

The dataset *PyramidApp configurations and participants behaviour* consist of records that can be used to reproduce the experimental results of an associated paper (Manathunga & Hernández-Leo, 2016a). In summary, the dataset includes details of learners' participation within scripted collaborative learning activities conducted in a secondary school and a vocational training school. The records included in the dataset offer learners' anonymised IDs, answers produced by the learners' to the collaborative learning task, and their participation within the specific collaborative learning mechanism proposed by the PyramidApp tool (Manathunga & Hernández-Leo, 2016b). The dataset also provides details of the activity authoring specified by the educators. The dataset is currently available under restricted access. The interested parties can request access to the dataset via Zenodo platform upon providing a justification regarding the intended use and upon agreeing to the data-sharing terms associated with the dataset.

The dataset *Teacher-led inquiry in technology-supported school communities* (Michos, Hernández-Leo, Albó, 2018a) consist of records related to the paper by Michos, Hernández-Leo, and Albó (2018b). In summary, the dataset consists of three different .pdf files, that describe data collected from secondary school teachers regarding their inquiry practices and additional information related to teachers' data-informed reflection with the use of TILE (Teacher Inquiry tool for Learning dEsigns) tool. The dataset is currently available under open access. As indicated in the Zenodo platform at the moment of writing the dataset has received 561 views and 550 downloads which exemplifies how storing and sharing research data in such open repositories promote open science.

Data collection and sharing have ethical implications which need to be carefully considered in responsible educational research, as discussed next.

3. Ethics in Educational Data Collection

One could argue that the risk of participating in educational technology research is growing as the pervasiveness and invasiveness of data being used increases. For example, data can be collected from activities outside of classrooms potentially providing greater insights into the private lives of participants (Lohr, 2012; Slade & Prinsloo, 2013), data can be aggregated from multiple sources to create more complete profiles of individuals, and health data such as that being collected from biosensors can reveal underlying medical conditions (Koenig et al., 2016) and personal attributes (Dantcheva, Elia & Ross, 2015). These are examples of how the complexity of technologies, techniques, and frameworks used to interpret data can obscure the riskiness of the data being collected to a layperson (Drachsler & Greller, 2016; Nissenbaum, 2011).

Despite its relevance, a very limited number of publications have looked into the ethical implications in educational technology research. For example, Beardsley, Santos, Hernández-Leo, & Michos (2019), members of TIDE-UPF, pointed out that only one article (Prinsloo & Slade, 2015) had addressed explicitly the topic of informed consent. Informed consent is the most common method of informing participants in educational technology research. This is a written document that should describe the participation in a clear and understandable manner so that final participants can make an informed decision whether or not to participate in the study. Through this written document an ethical obligation from educational researchers is to ensure an adequate understanding of the risks associated with the participation in the research (Drachsler & Greller, 2016).

As traditionally applied in other fields, such as biomedical research (Brody, 1998), educational technology researchers should ensure the application of ethical procedures in their research. In order to collect data in educational technology research involving human subjects it is necessary to fulfil basic ethics and personal data protection requirements. This section revises common ethics procedures in educational (technology) research and presents two cases that investigate facets of the informed consent process.

3.1 Ethics procedures in educational technology research

Ethics procedures are normally composed of two main stages: (1st stage) application for ethics review and approval from an ethical committee; (2nd stage) implementation of the ethical procedure in the educational setting.

Research ethics committees are constituted to review proposed studies with human participants to ensure that they conform to internationally and locally accepted ethical guidelines (1st stage). They can also monitor or follow-up action after the end of the research. Committees have the authority to approve, reject or stop studies or require modifications to research protocols (World Health Organization, 2009). Table 1 contains a summary of the main elements of the procedure, this list is based on the recommended ethical procedure provided by an existing ethical committee (CIREP, https://www.upf.edu/web/cirep/procedure) from Universitat Pompeu Fabra in Barcelona.

Table 1. Main elements in ethics procedures, an example of Universitat Pompeu Fabra in Barcelona

Element	Description
Self-assessment checklist	This first step is highly recommended to reflect on the main characteristics of the people involved in the study (e.g. people unable to give informed consent, vulnerable individuals, children/minors, patients or healthy volunteers, others), and the main methods and types of data that are planned to be collected. The European Commission (2019) provides guidance on how to complete your ethics self-assessment, covering most of the ethical issues arising in research projects and provides advice on dealing with classic cases.
Procedure form	A document describing the details of the educational context/environment where the research takes place, the scientific and research methods, main characteristics from participants, recruitment methods, and personal data processing strategies involved in the project.
Informed consent	A process to enable individuals to make voluntary decisions about participating in research based on an understanding of a study's purpose, procedures, risks, and benefits. A participant-oriented consent form will lead to better comprehension of informed consent as the information is presented in a manner that better aligns

	with the decision under consideration by the potential participant (Beardsley, Martínez Moreno, Vujovic, Santos, & Hernández-Leo, 2020).

Before the final submission of the application for approval from an ethical committee there is a pre-screening step where the committee checks if the documentation provided is completed or if further information is needed from the principal investigator. After this step is completed, the final step requires an ethical review from the committee (this can also involve external peer review from an independent expert). If the study involves the use of personal data processing, an expert in these matters reviews the adequacy of the documentation. For European countries it is required to be accomplished with General Data Protection Regulation (GDPR) (EU, 2016).

Once the documentation is approved by the ethical committee, educational technology researchers can proceed with the implementation of the ethical procedure in the educational setting (2nd stage). This will require informing the participants about the benefits and risks of the study through informed consent.

Although ethics procedures are in place in many research institutions, the intrinsic (and evolving) complexity of the topic has led the community to call for more empirical studies on ethics in educational technology research (Lin, 2007; Holmes, Iniesto, Sharples, & Scanlon, 2019). Descriptions of two such studies are presented below.

3.2 Meta-research on ethics in data collection: deficit in participant background knowledge

Communities of Teaching as a data-informed design science and contextualized practice (CoT) was a research project that encouraged teachers to approach their practice as a data-informed design science. As the project involved teachers making greater use of data, efforts were made to better understand what teachers and students knew about data management and work to increase their knowledge of data sharing risks and data management practices. As part of these efforts, an exploratory survey study involving 31 school teachers and 104 high school students was conducted (Beardsley, Santos, Hernández-Leo & Michos, 2019). Results revealed that none of the participating teachers had received formal training related to responsibly managing data. After a formative workshop, all participating teachers recognized the importance of receiving such training as they realized that their understanding of responsible data management was underdeveloped. Teachers commented that they had not known enough about appropriate protocols nor reflected sufficiently about the topic of managing student data responsibly. For students, results suggested that they regularly shared personal data online yet few had ever read user terms and conditions or privacy policies for any of the online applications they shared data with. Overall, students seemed to know they lacked knowledge of responsible data management and recognized a need for formal training in the subject matter.

The deficit in background knowledge about data sharing risks and data management practices raises concerns related to the validity of informed consent collected from teachers and students for educational technology research. It has been argued that research participants must adequately comprehend what they are consenting to in order for consent to be valid (Faden &

Beauchamp, 1986; Gallagher et al., 2010; Miller & Wertheimer, 2011; Cormack, 2016; Drachsler & Greller, 2016). Yet, research related to reading comprehension shows that lack of comprehension is often a result of low levels of background knowledge (Lipson, 1982; Kendeou & Van Den Broek, 2007; Kendeou & O'Brien, 2016). Biomedical studies often show that participants do not understand informed consent in medical contexts (Mandava, Pace, Campbell, Emanuel & Grady, 2012; Schenker, Fernandez, Sudore, & Schillinger, 2011) and a study by Campbell, Goldman, Boccia, and Skinner (2004) found that the level of reading comprehension was the factor that predicted the degree to which participants could recall informed consent information.

Despite the increasing riskiness of data collected in educational technology research, a structured literature review found only one article relating to informed consent in educational technology research had been published over the past 15 years. On the other hand, 24 such articles were published in bioethical literature in a single year (Beardsley, Santos, Hernández-Leo & Michos, 2019). As a result, a subsequent study described below was conducted to explore manners in which the informed consent process in educational technology research could be improved.

3.3 Meta-research on ethics in data collection: enhancing consent forms

As some recent technologies and techniques being adopted in MMLA come from biomedical research (e.g. those related to physiological measures), it is necessary to become more familiar with bioethical research to understand procedures developed to ethically use such technologies and techniques. Along these lines, results from bioethical studies indicate that enhancing consent forms is an efficient manner in which participant comprehension of informed consent can be improved thereby ethically supporting participant decision making and contributing toward validating the consent received by researchers (Flory & Emanuel, 2004; Nishimura et al., 2013). To explore whether enhancing consent forms can improve educational technology research participant understanding of informed consent without negatively impacting study enrolment rates, a quasi-experimental study with university students (n = 182) was conducted (Beardsley, Martínez Moreno, Vujovic, Santos & Hernández-Leo, 2020).

Firstly, bioethical literature was reviewed to identify best practices for enhancing consent forms. Two types of consent forms were created. One was written with a researcher orientation and the other a participant orientation. The researcher-oriented consent form was written from a third-person perspective and followed a commonly used structure by presenting the study objectives, methodology, collected data, risks and privacy, benefits, participation, and rights of participants. The participant-oriented consent form was written from a first-person perspective and the content was ordered considering points of interest of the reader (Dranseika, Piasecki, & Waligora, 2017) which led to requirements for participation and risks being presented first. Secondly, an objectively scored informed consent comprehension test for educational technology was created by adapting validated tests from the bioethical field (Joffe et al., 2001; Guarino et al., 2006; Sugarman et al., 2005).

Results indicated that overall comprehension did not differ between conditions. However, the participant-oriented consent form resulted in significantly lower rates of enrolment and higher levels of comprehension on test questions related to risk. Furthermore, the study was conducted in a compulsory academic course and results show that some participants noted feeling pressure to participate, inadequately informed about the study, and, overall, participant understanding of risk was poor. These findings highlight the need for additional studies that can better support potential research participants' understanding of and satisfaction with the informed consent process in educational technology research.

This need is aligned with the ideas behind the call for trustworthy AI and data-driven technologies, also in education, where the ethical challenge for supporting human understanding and agency is expected to be also considered in the design of educational (technology) interventions.

4. Trustworthy Data-Driven Educational Technology

As with AI systems (HLEG-AI, 2019), trustworthy data-driven educational technology should prevent and minimize their risks while still exploiting their benefits. This section presents two cases that attempt to exemplify how human-centered and well-being-driven design approaches offer paths for data-driven systems to respect human autonomy and the common good.

4.1 A case focused on supporting human agency with Learning Analytics

Computer-Supported Collaborative Learning (CSCL) is a widely adopted pedagogical practice that facilitates students' productive learning. Previous research has explored the conditions under which collaboration can be effective (e.g., group size, type of the learning task) and has shown that the quality of student interactions that occur during activity enactment is one of the major attributes that facilitate the achievement of productive collaborative learning outcomes. Teachers can foster such beneficial collaborative learning interactions among students during CSCL situations. However, to foster productive interactions teachers need to acquire a rigorous awareness regarding CSCL situations.

Learning Analytics (LA) is an area of research (Wise and Cui, 2018) that is concerned about measuring, collecting, analyzing, and reporting data about learners and the contexts in which learning occurs to enhance learning processes and outcomes (Siemens and Gašević 2012). The ever-increasing use of online learning platforms for teaching and learning has created an unprecedented opportunity to collect large amounts of digital data traces that depicts students' moment-to-moment learning interactions (Corrin et al., 2016). In the context of CSCL, where interactions are computer-mediated, LA can be effectively utilized to capture, extract and understand students' learning, and to report this information back to the teachers "closing the loop", creating opportunities for their meaningful interventions (Clow, 2012) increasing opportunities to enhance the real-time management or the orchestration.

Recently a growing research interest towards incorporating teacher-facing LA dashboards as tools to support everyday teaching practices has been observed. LA dashboards can be described as "single displays that aggregate different indicators about learner(s), learning process(es) and/or learning context(s) into one or multiple visualisations" (Schwendimann et al, 2016). Despite the growing research interest in deploying teacher-facing LA dashboards as tools to support teachers, the amount of support necessary for the teachers in interpreting and taking actions on LA dashboards in authentic collaborative learning situations is not fully understood yet (Wise and Jung, 2019). Exploring the type of support teachers require in order to be in control of the learning activity in-situ can help to broaden our understanding of how LA augments human agency.

To this end, following a within-subject study design we designed, deployed, and evaluated teacher-facing LA dashboards that implemented two different types of supports namely mirroring and guiding. The mirroring dashboards presented aggregated data about learning situations, e.g., students' interactions, unfolding of the script over time to the teachers for their reflection and action-taking (Soller et al. 2005). Similarly, the guiding dashboards presented aggregated data about learning situations, however, an additional warning mechanism that triggered automatic warnings was incorporated to warn teachers about critical moments that required their interventions and remedial actions. Six higher-education teachers (3 females) from the Engineering School of a public university in Spain evaluated the two different dashboards within 12 authentic classroom-based trials. Teachers' orchestration actions were recorded, coded, and subsequently analysed using the Epistemic Network Analysis (ENA) (Shaffer et al. 2016) to visualise and quantitatively compare the differences of orchestration actions across conditions. Teachers' subjective perceptions regarding the two supporting conditions were collected using subjective questionnaires which were then triangulated using mixed-methods to produce study findings. Teachers were also asked to score their perceived cognitive load reflecting the effort of orchestrating collaboration on a scale from 1 to 20 (1 low and 20 high).

In summary, the findings of the study (Amarasinghe, Hernández-Leo, Hoppe, 2021) indicated that in the mirroring condition teachers mostly engaged in making sense of the information presented in the dashboard. The exploration of the information has supported their interactions with the students at the class level, e.g., to provide directions and to criticise lack of participation. An important finding of the study indicated that in the mirroring condition, teachers missed the chances of reacting to critical script adaptations, e.g., changing the time, as they were more concerned about other information presented to them, e.g., students' answers. In the guiding condition, teachers mentioned that warnings helped to bring critical moments up front. As a result of teachers' reactions to warnings, necessary script adaptations came into effect, e.g., increasing the duration of script phases, providing adequate time for students to submit answers, and to evaluate answers from peers. Teachers also conducted more self-directed interventions apart from actions suggested by the warnings, e.g., posting messages to low participating groups. Hence, teachers' orchestration actions were found to benefit student collaboration in this context and are thus more beneficial in orchestrating collaboration compared to mirroring support. Overall guiding dashboards created a situation where teachers were seen to be in more control of the activity hence increased agency through data-driven insights obtained via LA. However, a relatively high cognitive load was recorded in the guiding condition when compared to the mirroring condition. This opens up a new research direction, which urges to deconstruct the notion of orchestration load which is defined as the "effort a teacher spends in coordinating multiple activities and learning processes" (Prieto et al., 2018), and to explore its different facets, which could guide to find the right balance between the amount of orchestration support required and the perceived cognitive load. Deconstructing the notion of orchestration load into different facets and understanding how different types of LA support contributes to it can shed light on how to design technologies that will lower the burden of orchestration hence contributing to the adoption of LA tools in classroom practice. In this line of research, we propose different facets of orchestration load namely, *situation evaluation, goal formation* and *action taking* derived through the lenses of teachers' actionable differences observed under different supporting conditions (Amarasinghe, Hernández-Leo, Hoppe, 2021).

A profound understanding of orchestration load and how it should be considered in the design of LA-driven support to educators is an example of caring for the human agency but also human well-being.

4.2 Educational technology and human well-being

As a result of the rapid deployment of digital technologies and their uptake by society, individual and societal 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 (Burr, Taddeo and Floridi, 2020). Moreover, the increasing use of data analytics and AI in the design and use of digital technologies make such ethical questions more urgent than ever before, and emphasise the need for these technologies to be guided by societal and ethical design principles to prioritize human well-being (IEEE Global Initiative on Ethics of A/IS, 2019). To investigate how educational technologies could impact human well-being considering the promising and concerning roles of LA, we applied the initial phase of the recently produced IEEE P7010 Well-being Impact Assessment WIA, a methodology and a set of metrics, to allow the digital well-being of a set of LA-supported educational technologies to be more comprehensively tackled and evaluated (Hakami and Hernandez-Leo, 2021).

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 (Floridi, 2012). The conception of well-being, however, should not be perceived as a one-dimensional value, but rather it 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 depends (IEEE Global Initiative on Ethics of A/IS, 2019). The global efforts toward evaluating the impact of the use of data analytics and AI on humans' well-being continue to establish societal guidelines for such systems to remain human-centric, serving humanity's values and ethical principles. These efforts include a recent production by the Institute of Electrical and Electronics Engineers (IEEE), a standard entitled P7010–2020 Recommended Practice for Assessing the Impact of Autonomous and Intelligent Systems on Human Well-being, which aims at establishing wellbeing metrics to enable well-being researchers as well as those creating data-driven technologies 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 (IEEE, 2020).

This study was conducted by applying the first task of the first activity of the IEEE p7010-2020 standard, initial internal analysis, to the creators of ten educational tools and services that were in different stages of the design lifecycle. We asked the creators to clearly identify each tool's goals, users, and stakeholders before they applied internal analysis activities (e.g., projecting, hypothesizing, utilizing scenarios) to select indicators that could reflect positive and/or negative impacts on 12 well-being domains: satisfaction with life, affect, psychological well-being, community, culture, education, economy, environment, government, health (physical and mental), human settlement, and work.

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., the standard of living), environment, human settlement (i.e., ICT) and government (i.e., sense of democracy).

5. Conclusions

This chapter approaches the concept of responsible research in the educational technology research field from different - but complementary - angles, i.e., open science and data, ethics in data collection and ethics in the design of technologies. The chapter introduces notions and elements behind each angle and illustrates them with procedures, efforts and studies carried out by the Interactive and Distributed Technologies for Education (TIDE) research group at Universitat Pompeu Fabra in Barcelona.

Open Science is an ongoing movement that promotes transparent and frequent open-access updates of the research progress and the collected data; and at the same time, reproducible, accurate and verifiable research, bringing benefits for the individual researchers, the research community and the society. Reproducibility is an important aspect of Open Science as "scientific claims should not gain credence because of the status or authority of their originator but by the replicability of their supporting evidence" (Open Science Collaboration, 2015). Nevertheless, there are a number of challenges to face in replicating educational research studies, including those using learning analytics - as illustrated in this chapter with the case of multimodal learning analytics. MMLA work often requires researchers to develop new competencies related to using specialized equipment (Schmidt, 2009), methods of data acquisition, cleaning, analysis, and reporting (Carp, 2012), and in making of methods, data, code, and workflows openly available (Stodden et al., 2016). Platforms, such as Zenodo, offer useful features to facilitate the publication of open data and the other information relevant to the workflow. Ethics is a key transversal aspect to be considered in this workflow.

Ethics perspectives in educational technology research are not only relevant in the collection and sharing of data but also in the design and development of technologies, especially when they are based on data analytics or artificial intelligence techniques. Studies summarized in this chapter point out that ethics procedures should be aware of challenges associated with the background knowledge of participants in terms of data management and sharing and that efforts are needed to understand how to better support potential research participant comprehension and satisfaction with the informed consent process in educational technology research. On the other hand, the design of AI and data-driven learning technologies need to be aware of ethical considerations. These considerations go beyond data collection and relate to finding low-risk beneficial trade-offs in the tension between automating decisions and supporting human agency and wellbeing. Human-centred design of learning analytics solutions offers a promising methodology to address this tension. This chapter provides an example of a study involving the stakeholders (teachers in the case of the example) that aimed at finding the right synergy between humans and machines in decision-making aspects involved in teaching and learning processes (Amarasinghe & Hernández-Leo, 2021)

Moreover, the current or future responsible integration of learning analytics into educational technologies should 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. The chapter contributes with an example where participants found the IEEE P7010-2020 recommended practice promising to promote LA practices to increase student and teacher well-being. However, the focus of the summarized study on only tools' creators represents a start point toward a systematic and iterative assessment process of 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.

This book has a focus on data and this chapter offers contributions to the ways in which a data culture is generated in Higher Education institutions. Yet, it is important to recognize that there are other angles in responsible research not tackled in the chapter that are also crucial in educational (technology) research. These angles include public engagement, gender, sustainability, science education or inclusion. The TIDE research group at UPF is committed to gender and international diversity, as reflected in its composition (currently over 20 members with equal gender balance and 13 different nationalities), and has started to incorporate the gender, science education and inclusion perspectives determinedly in their studies (e.g., Vujovic et al., 2021; Martínez, Santos & Hernández-Leo, 2021). Mutual inspiration through shared good practices in all angles of responsibility in data and science cultures in educational research will definitely contribute to better science with increasingly positive social impact.

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Appendix D- INTERNAL ANALYSIS FOR ASSESSING THE WELLBEING IMPACT OF LA-SUPPORTED LEARNING TECHNOLOGIES

The content of this section is a survey developed and used to facilitate the first phase of IEEE P7010 recommended practice, i.e., internal analysis. The data collected from this survey was used in section 2.3, and can be found in:

Hakami, E., & Hernández-Leo, D.: Internal analysis for assessing the wellbeing impact of LA-supported learning technologies [Data set]. Zenodo (2021). https://doi.org/10.5281/zenodo.5810444

Internal analysis for Well-being Impact Assessment

Based on IEEE P7010 recommended practice for Well-being Impact Assessment WIA

*Required

Overview

This activity is a part of a broader framework that aims at proposing and evaluating useful practice for educational technologists and LA researchers in order to support them in assessing and improving the impact of their systems on human well-being.
To measure the well-being impact of LA-supported educational technologies, we have first to identify a set of indicators that takes in consideration the different goals and users of each system. These indicators are essential for measuring possible impacts of your system/service on various well-being aspects of users, stakeholder and the society.

Objectives

This activity is an internal analysis conducted by systems' creators to initially identify well-being indicators that reflect potential well-being impacts of these systems on users, stakeholders and the society.

This analysis should answer the following questions:
- What is your system/technology?
- What is the need it meets/ goal it seeks/ problem it solves?
- Who are the intended and unintended users and who are the stakeholders?
- What are the possible impacts on human well-being, the probability of their occurrence? and how are negative impacts on human well-being are considered and prevented?

By answering the four questions above, you should have both understanding and grasp on limits of understanding of how your system may have positive and/or negative impacts on human well-being.

Definitions

- Well-being: the continuous and sustainable physical, mental, and social flourishing of individuals, communities and populations where their economic needs are cared for within a thriving ecological environment.

- Well-being metrics: subjective and objective indicators - indicators measuring both internal phenomena and external factors - encompassing the capabilities and subjective well-being approaches, and including but limited to the domains of (1) satisfaction with life, (2) affect, (3) psychological well-being, (4) community, (5) culture, (6) education, (7) economy, (8) environment, (9) human settlements, (10) health, (11) government, and (12) work.

- User: a person who interacts with your system. A user is a type of stakeholder.

- Intended user: a person who you intend your system to be used by.

- Unintended user: a person who you do not intend your system to be used by, but who nonetheless interacts with it.

- Non-user stakeholder: a stakeholder who is not a user.

- Stakeholder: anyone or any organization that is 1) meaningfully or potentially meaningfully be impacted by your system and/or 2) meaningfully or potentially meaningfully impacts the system.

- Domain: an aspect or area of knowledge or activity characterized by a set of concepts and terminology understood by practitioners in that area

- Indicator: a measure of a discrete element of a domain. One domain has one or more indicators.

Tips

- Begin with an assumption that your system impacts all well-being domains.
- Read the definition of each domain and subdomain and think of your users, stakeholders and the society.
- Read each indicator, forecast, hypothesize, project, and utilize scenarios to decide which indicators reflect potential impacts of your system.
- Be attentive to both positive and negative impacts.
- Be attentive to both intended and unintended impacts.
- Consider unintended and unexpected issues, such as potential biases and think how risks and negative impacts to human well-being can be mitigated

Duration

This activity takes about 2 hours.

1. Your name and surname *

2. Your Email *

3. What is the title/category of your system/tool/service? *

e.g, PyramidApp, a computer-supported collaborative learning tool

4. Describe your system/tool/service (need it meets/ goal it seeks/ problem it solves) *

e.g, a web-based tool which facilitates teachers to design and deploy Pyramid-pattern based collaborative learning activities. In a classroom session, the tool facilitates allocating students into multiple Pyramids (groups) and for reaching a consensus for a given task following a Pyramid structure. The tool provides an activity authoring space and an orchestration dashboard for teachers.

5. Who are the users of your system/tool/service *

e.g, teachers, learners

6. Who are the stakeholders of your system/tool/service *

e.g, School community members (Teachers, learners, academic managers, families, other school staff)

1. Domain of 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.

7. Check if any of the following indicators reflect a possible impact of your system. Place your check to the impacted party/parties.

Tick all that apply.

	Users	Stakeholders	Society
Sense that one's life is the best to worst possible life for them at the time	☐	☐	☐
Satisfaction with life as a whole	☐	☐	☐
How satisfied are you with your life nowadays	☐	☐	☐

8. Explain/justify your selections if any made (optional)

2. Domain of Affect

The domain of affect is defined to include positive and negative feeling. The terms feelings, mood or emotions are also be used. The indicators are be used to measure affect in the moment, or how a person is feeling in the moment, or a lasting emotional experience, such as frequently feeling anxious or depressed.

9. Check if any of the following indicators reflect a possible impact of your system. Place your check to the impacted party/parties.

Tick all that apply.

	Users	Stakeholders	Society
Positive affects: feeling happy, calm, peaceful, etc.	☐	☐	☐
Negative affects: feeling sad, depressed, anxious, etc.	☐	☐	☐

10. Explain/justify your selections if any made (optional)

____

3. Domain of 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”. The terms flourishing or eudaimonia is also used.

11. Check if any of the following indicators reflect a possible impact of your system. Place your check to the impacted party/parties.

Tick all that apply.

	Users	Stakeholders	Society
Sense that one leads a purposeful and meaningful life	☐	☐	☐
Feeling that the things one does are worthwhile	☐	☐	☐
Sense one is capable and good at what they do	☐	☐	☐

12. Explain/justify your selections if any made (optional)

____

4. Domain of Community

Community is defined as “a group of people living in the same place or having a particular characteristic in common.
The domain of community encompasses sense of belonging, community participation, social support, safety and discrimination.

4.1. Sense of belonging

Sense of belonging is defined as "a feeling that (people) matter to one another and to the group, and a shared faith that (people's) needs will be met through their commitment to be together.

13. Check if any of the following indicators reflect a possible impact of your system. Place your check to the impacted party/parties.

Tick all that apply.

	Users	Stakeholders	Society
Sense of belonging to a neighborhood	☐	☐	☐
Sense that one sees oneself as part of a community.	☐	☐	☐

14. Explain/justify your selections if any made (optional)

____

4.2. Community participation

Community participation includes activism, volunteerism and donations.

15. Check if any of the following indicators reflect a possible impact of your system. Place your check to the impacted party/parties.

Tick all that apply.

	Users	Stakeholders	Society
Approximate total hours a month one was active in voluntary organizations	☐	☐	☐
Donations to a charity in a month	☐	☐	☐

16. Explain/justify your selections if any made (optional)

____

4.3. Social support

Social support is defined as the assistance and help that people give and receive from each other

17. Check if any of the following indicators reflect a possible impact of your system. Place your check to the impacted party/parties.

Tick all that apply.

	Users	Stakeholders	Society
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	☐	☐	☐
Satisfaction with relationships	☐	☐	☐

18. Explain/justify your selections if any made (optional)

____

4.4. Community safety

Community safety should be defined as going about "daily life without fear or risk of harm or injury

19. Check if any of the following indicators reflect a possible impact of your system. Place your check to the impacted party/parties.

Tick all that apply.

	Users	Stakeholders	Society
Feeling safe walking alone around the area where they live	☐	☐	☐
Sense that most people can be trusted or that one needs to be very careful in dealing with people	☐	☐	☐
Crimes against the person per 1000 adults	☐	☐	☐

20. Explain/justify your selections if any made (optional)

____

4.5. Discrimination

Discrimination is defined for any group as "any distinction, exclusion, restriction or preference ... which has the purpose or effect of nullifying or impairing the recognition, enjoyment or exercise, on an equal jogging, of human rights and fundamental freedoms in the political, economic, social, cultural or any other field of public life

21. Check if any of the following indicators reflect a possible impact of your system. Place your check to the impacted party/parties.

Tick all that apply.

	Users	Stakeholders	Society
Proportion of persons victim of physical or sexual harassment, by sex, age, disability status and place of occurrence, in the previous 12 months	☐	☐	☐
Sense of discrimination in one's neighborhood or community	☐	☐	☐

22. Explain/justify your selections if any made (optional)

____

5. Domain of 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.
The domain of culture encompasses arts, customs, and other aspects of culture.

23. Check if any of the following indicators reflect a possible impact of your system. Place your check to the impacted party/parties.

Tick all that apply.

	Users	Stakeholders	Society
Engagement with / participation in arts or cultural activity	☐	☐	☐

24. Explain/justify your selections if any made (optional)

____

6. Domain of Education

The domain of education encompasses formal education and lifelong learning

6.1 Formal Education

Formal education is defined as "training typically provided by an education or training institution, structured (in terms of learning objectives, learning time or learning support) and leading to certification.
Formal learning is intentional from the learner's perspective

25. Check if any of the following indicators reflect a possible impact of your system. Place your check to the impacted party/parties.

Tick all that apply.

	Users	Stakeholders	Society
Average years of schooling	☐	☐	☐
Satisfaction with educational systems or schools in area in which one lives	☐	☐	☐

6.2 Lifelong learning

Lifelong learning is defined by (Eurostat [BXX]) as composed of people aged 25 or older in education and training.

26. Check if any of the following indicators reflect a possible impact of your system. Place your check to the impacted party/parties.

Tick all that apply.

	Users	Stakeholders	Society
Access to opportunities to learn	☐	☐	☐
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	☐	☐	☐

27. Explain/justify your selections if any made (optional)

____

7. Domain of Economy

Economy is defined as local and extended networks of inputs of land, labor, and capital and enterprises (the four factors of production) and other human activities. (Johnson, 1995 [BXX]). Collins Dictionary [BXX] defines economy 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 & production; and business & entrepreneurship.

7.1 Standard of living

Standard of living is defined as “the level of comfort and wealth which you have."

28. Check if any of the following indicators reflect a possible impact of your system. Place your check to the impacted party/parties.

Tick all that apply.

	Users	Stakeholders	Society
Household Net Financial Wealth	☐	☐	☐
Satisfaction with the financial situation of one's household	☐	☐	☐
Average gross national income in purchasing power parity	☐	☐	☐
Proportion of adults (15 years and older) with an account at a bank or other financial institution or with a mobile-money-service provider	☐	☐	☐

29. Explain/justify your selections if any made (optional)

____

7.2 Economic equity and equality

Economic equity and equality is defined as "The situation in an economy in which the apportionment of resources or goods among the people is considered fair "

30. Check if any of the following indicators reflect a possible impact of your system. Place your check to the impacted party/parties.

Tick all that apply.

	Users	Stakeholders	Society
Income inequality or rich-poor gap or Gini index	☐	☐	☐
How often a family goes without enough food to eat	☐	☐	☐

31. Explain/justify your selections if any made (optional)

____

7.3 Jobs

Jobs are defined as "a paid position of regular employment, a task or piece of work, especially one that is paid "

32. Check if any of the following indicators reflect a possible impact of your system. Place your check to the impacted party/parties.

Tick all that apply.

	Users	Stakeholders	Society
Unemployment rate, by sex, age and persons with disabilities	☐	☐	☐
Degree to which one is worried about losing their job or not finding a job	☐	☐	☐

33. Explain/justify your selections if any made (optional)

7.4 Natural resources, consumption & production

Sustainable consumption is "the use of services and related products which respond to basic needs and bring a better quality of life while minimizing the use of natural resources and toxic materials as well as emissions of waste and pollutants over the life cycle of the service or product so as not to jeopardize the needs of future generations."
Sustainable consumption and production is "about promoting resource and energy efficiency, sustainable infrastructure, and providing access to basic services, green and decent jobs and a better quality of life for all "

34. Check if any of the following indicators reflect a possible impact of your system. Place your check to the impacted party/parties.

Tick all that apply.

	Users	Stakeholders	Society
Recycling rates	☐	☐	☐
Material consumption	☐	☐	☐

35. Explain/justify your selections if any made (optional)

7.5 Business and entrepreneurship

Business is "a project or venture undertake for gain."
Entrepreneurship is "the capacity and willingness to develop, organize and manage a business venture along with any of its risks in order to make a profit. The most obvious example of entrepreneurship is the starting of new businesses.

36. Check if any of the following indicators reflect a possible impact of your system. Place your check to the impacted party/parties.

Tick all that apply.

	Users	Stakeholders	Society
Proportion of small-scale industries in total industry value added	☐	☐	☐
Sense that the area where one lives is a good place to live for entrepreneurs forming a new business	☐	☐	☐

37. Explain/justify your selections if any made (optional)

____

8. Domain of Environment

Environment is defined as "climate, weather, and natural resources that affect human survival and economic activity "

The domain of the environment encompasses the environment in general, climate change, air, water, soil, and biodiversity.

8.1 Environment general indicators

38. Check if any of the following indicators reflect a possible impact of your system. Place your check to the impacted party/parties.

Tick all that apply.

	Users	Stakeholders	Society
Satisfaction with efforts to preserve the environment	☐	☐	☐
Non-compliance with environmental laws and regulations	☐	☐	☐
Proportion of urban solid waste regularly collected and with adequate final discharge out of total urban solid waste generated, by cities	☐	☐	☐

39. Explain/justify your selections if any made (optional)

____

8.2 Climate change

Climate change is defined as "any change in climate over time, whether due to natural variability or as a result of human activity "

40. Check if any of the following indicators reflect a possible impact of your system. Place your check to the impacted party/parties.

Tick all that apply.

	Users	Stakeholders	Society
Reduction of Greenhouse Gas Emissions	☐	☐	☐
Reduction of energy consumption	☐	☐	☐
Proportion of population with primary reliance on clean fuels and technology	☐	☐	☐
How much (people) know about global warming or climate change	☐	☐	☐

41. Explain/justify your selections if any made (optional)

8.3 Air

Air quality is determined from "levels of, and length of exposure to, pollution resulting in adverse effects on human health and well-being "

42. Check if any of the following indicators reflect a possible impact of your system. Place your check to the impacted party/parties.

Tick all that apply.

	Users	Stakeholders	Society
Degree of satisfaction with the quality of air	☐	☐	☐
Annual mean levels of fine particulate matter	☐	☐	☐

43. Explain/justify your selections if any made (optional)

8.4 Water

Water includes rivers, lakes, oceans, rain and aquifers and "is the basis of the fluids of living"

44. Check if any of the following indicators reflect a possible impact of your system. Place your check to the impacted party/parties.

Tick all that apply.

	Users	Stakeholders	Society
Change in water-use efficiency over time	☐	☐	☐
Satisfaction with quality of water	☐	☐	☐
Proportion of bodies of water with good ambient water quality	☐	☐	☐
Proportion of wastewater safely treated	☐	☐	☐
Percentage of households with year round access to water	☐	☐	☐

45. Explain/justify your selections if any made (optional)

8.5 Soil

Soil is the "upper layer of earth, a mixture of organic and inorganic matter, in which plants grow. It is a finite natural resource. On a human time-scale it is non-renewable ”

46. Check if any of the following indicators reflect a possible impact of your system. Place your check to the impacted party/parties.

Tick all that apply.

	Users	Stakeholders	Society
Crop yield gap -actual yield as% of attainable yield	☐	☐	☐
Nitrogen use efficiency in food systems	☐	☐	☐
Proportion of agricultural area under productive and sustainable agriculture	☐	☐	☐

47. Explain/justify your selections if any made (optional)

8.6 Biodiversity

Biodiversity is the range of genetic differences, species differences and ecosystem differences in a given area. Biological diversity is" the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part: this includes diversity within species, between species and of ecosystems "

48. Check if any of the following indicators reflect a possible impact of your system. Place your check to the impacted party/parties.

Tick all that apply.

	Users	Stakeholders	Society
Endangered and threatened species: IUCN Red List species and national conservation list species in areas affected by (company) operations	☐	☐	☐
Habitats protected or restored	☐	☐	☐
Forest area as a proportion of total land area	☐	☐	☐

49. Explain/justify your selections if any made (optional)

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9. Domain of 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 ”. The domain of government encompasses human rights, institutions, civil participation and trust.

9.1 Human rights

Human rights are defined as “(1) civil and political rights, such as the right to life, equality before the law and freedom of expression; (2) economic, social and cultural rights, such as the rights to work, social security and education, or (3) collective rights, such as the rights to development and self-determination ".

50. Check if any of the following indicators reflect a possible impact of your system. Place your check to the impacted party/parties.

Tick all that apply.

	Users	Stakeholders	Society
Sense there is respect for individual human rights nowadays in one's country	☐	☐	☐
Sense there is freedom of assembly, demonstration, and open public discussion	☐	☐	☐
Sense there is equality of opportunity and the absence of economic exploitation	☐	☐	☐
Victims of human trafficking per 100,000 population, by sex, age and form of exploitation	☐	☐	☐
Laws, policies, and practices guarantee equal treatment of various segments of the population	☐	☐	☐

51. Explain/justify your selections if any made (optional)

9.2 Institutions

Institutions are "a complex of positions, roles, norms and values lodged in particular types of social structures and organizing relatively stable patterns of human activity". A government agency is an "organization in the machinery of government that is responsible for the oversight and administration of specific functions, such as an intelligence agency".

52. Check if any of the following indicators reflect a possible impact of your system. Place your check to the impacted party/parties.

Tick all that apply.

	Users	Stakeholders	Society
Satisfaction with one's last experience of public services	☐	☐	☐
Rule of law prevailing in civil and criminal matters	☐	☐	☐
Registration of voters and candidates conducted in an accurate, timely, transparent, and nondiscriminatory manner	☐	☐	☐
Sense elections are fair	☐	☐	☐
Citizens having the legal right and practical ability to obtain information about government operations and the means to petition government agencies for it	☐	☐	☐
Defendants given a fair, public, and timely hearing by a competent, independent, and impartial court	☐	☐	☐
Print, broadcast, and / or internet-based media are not directly or indirectly censored	☐	☐	☐
Trade unions are allowed to be established and to	☐	☐	☐

operate free from government interference

53. Explain/justify your selections if any made (optional)

9.3 Civil engagement

Civic Engagement is defined as "working to make a difference in the civic life of our communities and developing the combination of knowledge, skills, values and motivation to make that difference. It means promoting the quality of life in a community, through both political and non-political processes".

54. Check if any of the following indicators reflect a possible impact of your system. Place your check to the impacted party/parties.

Tick all that apply.

	Users	Stakeholders	Society
Voter turnout	☐	☐	☐
Cultural, ethnic, religious, or other minority groups have full political rights and electoral opportunities	☐	☐	☐
Attendance of peaceful demonstrations in the last year	☐	☐	☐
Signing a petition (s) in the last year	☐	☐	☐

55. Explain/justify your selections if any made (optional)

9.4 Trust in government

Trust in government is defined as "(citizens believing) the system and political incumbents to be responsive, honest, and competent, even in the absence of constant scrutiny.".

56. Check if any of the following indicators reflect a possible impact of your system. Place your check to the impacted party/parties.

Tick all that apply.

	Users	Stakeholders	Society
Sense of confidence in government - national, local, civil service, judicial system, police, political parties. etc.	☐	☐	☐
Sense that government is free from pervasive corruption	☐	☐	☐
Percentage of households with year round access to water	☐	☐	☐

57. Explain/justify your selections if any made (optional)

____

10. Domain of health

Health is defined as "a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity".
The domain of health include physical health and mental health.

10.1 Physical health

Physical health is defined as "(relating) to the functioning of the physical body. There are many diseases, conditions and disabilities that can impair functioning ".

58. Check if any of the following indicators reflect a possible impact of your system. Place your check to the impacted party/parties.

Tick all that apply.

	Users	Stakeholders	Society
Healthy life expectancy	☐	☐	☐
Sense that one's state of health is good	☐	☐	☐
Sense of having enough energy to get things done	☐	☐	☐
Satisfaction with quality of health care	☐	☐	☐
Obesity in adults and adolescents	☐	☐	☐
Out-of-pocket payment for health	☐	☐	☐
Coverage of essential health services - defined as the average coverage of essential services based on tracer interventions that include reproductive, maternal, newborn and child health, infectious diseases, non-communicable diseases and service capacity and access, among the general and the most disadvantaged population	☐	☐	☐
Proportion of women of reproductive age (aged 15–49 years) who have their need for family planning satisfied with modern methods	☐	☐	☐

methods

59. Explain/justify your selections if any made (optional)

____

10.2 Mental health

Mental health is "a state of well-being in which the individual realizes his or her own abilities, can cope with the normal stresses of life, can work productively and fruitfully, and is able to make a contribution to his or her community ".

60. Check if any of the following indicators reflect a possible impact of your system. Place your check to the impacted party/parties.

Tick all that apply.

	Users	Stakeholders	Society
Coverage of services for severe mental health disorders	☐	☐	☐
Suicide attempts	☐	☐	☐
Number of persons who have seen a health professional during a year	☐	☐	☐
Projects to support parenting skills	☐	☐	☐
Lost workdays due to mental disorder or substance use	☐	☐	☐

61. Explain/justify your selections if any made (optional)

____

11 Domain of human settlements

Human settlements is defined as geographical areas where people live.
The domain of human settlements encompasses housing, food, transportation, and information and communications technology.

11.1 Human settlement general indicators

Human settlements is defined geographically and include densely populated areas (cities), intermediate density areas (towns and suburbs) and thinly populated areas (rural areas).

62. Check if any of the following indicators reflect a possible impact of your system. Place your check to the impacted party/parties.

Tick all that apply.

	Users	Stakeholders	Society
Area of public and green space as a proportion of total city space	☐	☐	☐
Satisfaction with beauty or physical setting	☐	☐	☐
Proportion of population living in households with access to basic services	☐	☐	☐

63. Explain/justify your selections if any made (optional)

____

11.2 Housing

Housing is defined as “a safe and secure home and community in which to live in peace and dignity" .

64. Check if any of the following indicators reflect a possible impact of your system. Place your check to the impacted party/parties.

Tick all that apply.

	Users	Stakeholders	Society
Satisfaction with quality of housing	☐	☐	☐
Satisfaction with availability of good affordable housing	☐	☐	☐
Proportion of urban population living in slums, informal settlements or inadequate housing	☐	☐	☐
Defendants given a fair, public, and timely hearing by a competent, independent, and impartial court	☐	☐	☐
Print, broadcast, and / or internet-based media are not directly or indirectly censored	☐	☐	☐
Trade unions are allowed to be established and to operate free from government interference	☐	☐	☐

65. Explain/justify your selections if any made (optional)

11.3 Food

Food is defined in terms of food security as having at all times "physical, social and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life".

66. Check if any of the following indicators reflect a possible impact of your system. Place your check to the impacted party/parties.

Tick all that apply.

	Users	Stakeholders	Society
Prevalence of undernourishment	☐	☐	☐
Secure access to food	☐	☐	☐

67. Explain/justify your selections if any made (optional)

____

11.4 Transportation

Transportation is defined as “the provision of services and infrastructure for the mobility of people and goods— advancing economic and social development to benefit today's and future generations — in a manner that is safe, affordable, accessible, efficient, and resilient, while minimizing carbon and other emissions and environmental impacts ”.

68. Check if any of the following indicators reflect a possible impact of your system. Place your check to the impacted party/parties.

Tick all that apply.

	Users	Stakeholders	Society
Proportion of population that has convenient access to public transport, by sex, age and persons with disabilities	☐	☐	☐
Satisfaction with transportation system in the city or area one lives	☐	☐	☐
Death rate due to road traffic injuries	☐	☐	☐

69. Explain/justify your selections if any made (optional)

11.5. Information and communications technology (ICT)

Information and communications technology (ICT) is defined as “the set of activities which facilitate by electronic means the processing, transmission and display of information”. ICTs "refer to technologies people use to share, distribute, gather information and to communicate, through computers and computer networks”.

70. Check if any of the following indicators reflect a possible impact of your system. Place your check to the impacted party/parties.

Tick all that apply.

	Users	Stakeholders	Society
Proportion of population covered by a mobile network, by technology	☐	☐	☐
Having a cellular phone	☐	☐	☐
Access to internet at home	☐	☐	☐
Having a computer at home	☐	☐	☐
Proportion of youth and adults with information and communications technology (ICT) skills, by type of skill	☐	☐	☐

71. Explain/justify your selections if any made (optional)

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12. Domain of work

Work is defined as an activity involving mental or physical effort done in order to achieve a purpose or result and as including both paid and unpaid work, such as homemaker, volunteer, etc.
The domain of work encompasses workplace governance, workplace environment and work life balance.

12.1 Workplace governance

Workplace governance is defined as "corporate governance broadly (referring) to the mechanisms, relations, and processes by which a corporation is controlled and is directed; involves balancing the many interests of the stakeholders of a corporation ".

72. Check if any of the following indicators reflect a possible impact of your system. Place your check to the impacted party/parties.

Tick all that apply.

	Users	Stakeholders	Society
Diversity of governance bodies and employees	☐	☐	☐
Identifying and managing economic, environmental, and social impacts	☐	☐	☐
Operations with local community engagement, impact assessments, and development programs	☐	☐	☐
Operations that have been subject to human rights reviews or impact assessments	☐	☐	☐
Mechanisms for advice and concerns about ethics	☐	☐	☐
Communication and training about anti-corruption policies and procedures	☐	☐	☐

73. Explain/justify your selections if any made (optional)

12.2 Workplace environment

Workplace environment is the "physical conditions, such as office temperature, or equipment, such as personal computers. It can also be related to factors such as worH processes or procedures".

74. Check if any of the following indicators reflect a possible impact of your system. Place your check to the impacted party/parties.

Tick all that apply.

	Users	Stakeholders	Society
Satisfaction with job	☐	☐	☐
Sense that current work life is interesting	☐	☐	☐
Sense that one's supervisor has respect for and cares about one's welfare	☐	☐	☐
Sense that one gets support and help from co-workers	☐	☐	☐
Satisfaction with opportunities for professional development and promotion in one's current primary job	☐	☐	☐
Sense that the conditions of one's job allows one to be about as productive as one could be	☐	☐	☐
Sense of independence one has in performing tasHs at worH	☐	☐	☐
Workers representation in formal joint management – worHer health and safety committees	☐	☐	☐
Satisfaction with salary and benefits in current primary job	☐	☐	☐
Ratio of basic salary	☐	☐	☐

and remuneration of women to men			
Expected earnings loss, measured as the percentage of the previous earnings, associated with unemployment	☐	☐	☐
Percentage of employees receiving regular performance and career development reviews	☐	☐	☐
Average hours of training per year per employee	☐	☐	☐
Types of injury and rates of injury, occupational diseases, lost days, and absenteeism, and number of work-related fatalities	☐	☐	☐

75. Explain/justify your selections if any made (optional)

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12.3 Work life balance

Work life balance is "a situation in which you are able to give the right amount of time and effort to your work and to your personal life outside work, for example to your family or to other interests."

76. Check if any of the following indicators reflect a possible impact of your system. Place your check to the impacted party/parties.

Tick all that apply.

	Users	Stakeholders	Society
Satisfaction with the balance between the time spent on the job and the time spent on other aspects of life	☐	☐	☐
Proportion of employed people working 50 hours or more a week	☐	☐	☐
Average amount of time spent on leisure time out of doors, away from home in previous 12 months	☐	☐	☐

77. Explain/justify your selections if any made (optional)

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Reflection on process

78. Have possible impacts on human well-being been identified? *

Mark only one oval.

- ◯ Yes
- ◯ No
- ◯ Not sure

79. Explain your answer

80. Were unintended and unexpected issues considered, such as potential biases, negative impacts, and other unknowns considered, including how risks and negative impacts to human well-being can be mitigated? *

Mark only one oval.

- Yes
- No
- Not sure

81. Explain your answer

82. Has this activity increased your awareness of well-being domains and indicators that are relevant to your system? *

Mark only one oval.

- Yes
- No
- Not sure

83. Explain your answer

84. Has this activity increased your capacity to address and evaluate the impact of your system on well-being? *

Mark only one oval.

- Yes
- No
- Not sure

85. Explain your answer