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

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Analytics.

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).

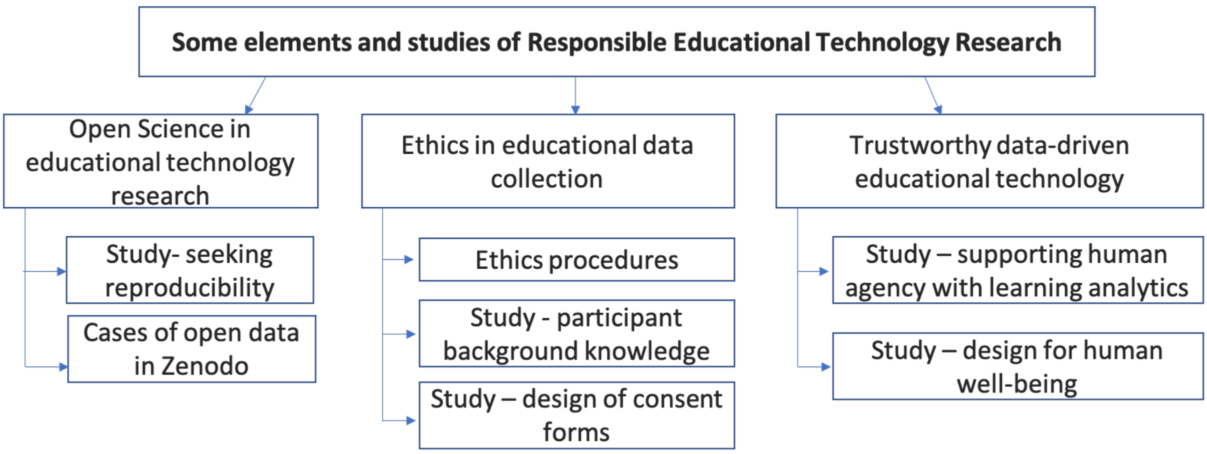

Figure 1. Elements of Responsible Educational Technology Research addressed in the chapter

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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