Exploring Education Techno-Monitoring Futures: A Participatory Speculative Critical Design Case

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Abstract. In learning and education, techno-monitoring practices are a growing trend. While these practices are still emerging, there has been no public debate on education stakeholders' preferred futures regarding techno-monitoring in learning and education. This study presents a participatory design case using speculative critical design to support higher education students' reflection about possible futures related to techno-monitoring practices in learning in higher education. The participants' experiences using a prototype that monitors mental states are presented in the form of stories, which reflect the students' complex relations toward techno-monitoring. Participatory speculative critical design is highlighted as a successful strategy to create compelling futures scenarios that trigger critical reflection and debate among the education community.

Keywords: Speculative critical design, participatory design, education futures, ethnographic experiential futures.

1 Introduction

During the last decade, individuals have increasingly adopted diverse forms of techno-monitoring practices, such as lifelogging, personal informatics, the Quantified Self, and personal analytics (e.g., [1]). The affordability of wearable devices using sensor-based technologies has enabled automatic data collection on many aspects of people's lives, including their physical activity, sleep, and emotions. The data collected through these technologies is expected to support self-understanding and, potentially, to foster behavioral change.

In education, automatic collection of data on academic activity has become popular through the implementation of Learning Analytics (LA) as part of online learning environments. In these contexts, the analysis of students' data is expected to lead to a deeper understanding of students' behaviors, supporting the adaptation and personalization of learning [2]. Since 2017, technology forecast reports have highlighted learning measurement as a growing trend at all education levels [3], [4], [5]. The massive implementation of online teaching and learning during the COVID-19 pandemic has contributed to accelerating the digitalization of teaching and learning in formal education systems [6].

Although techno-monitoring in learning and education has focused on tracking students' activity in online environments, the adoption of practices such as the

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Quantified Self in informal and formal education has been considered a possible future [7]. In fact, the growing corpus of research on student techno-monitoring in the field of Technology-Enhanced Learning (TEL) (see [8] for a review of sensor-based technology in TEL) could be viewed as a signal of the expansion of the datafication of learning, from a student-centered perspective.

In this article, I present a design case exploring a possible future around the implementation of techno-monitoring practices in learning and education using an ethnographic experiential futures approach. As part of the research, a critical speculative design focused on the techno-monitoring of students' mental states has been implemented. In the following sections, I introduce the theoretical background as well as the methodology used in the study. The research results are presented in the form of stories. I discuss the stories, connecting them with broader narratives. The final remarks highlight issues to consider in relation to education and learning techno-monitoring.

2 Speculating about Possible Futures

As discussed in the introduction, the datafication of learning through techno-monitoring practices is likely to intensify in the coming years. According to Facer, education is strongly interlinked with futurity since classrooms are sites in which futures can be shaped or contested [9]. The anticipation of possible futures related to techno-monitoring in learning and education enables creating a space in the present to discuss fears and hopes regarding the future [10]. From this perspective, critical anticipation is a strategy for raising awareness and triggering discussion.

According to critical futures scholarship, the future cannot be predicted [11], but speculating about futures, distinguishing what is probable, what is possible, and what is preferable, can give rise to diverse views, stressing the idea that many futures are possible, and they are actively constructed [12]. In education, studies have already been conducted to identify and debate possible education technology futures [13], [14] and schooling models [15] as well as to discuss issues in education beyond 2030 [16].

The speculation around possible futures, even dystopian scenarios, has been considered valuable for supporting public debate to articulate what a preferable future might look like [17]. While scenarios aim to depict concrete images of possible futures to make thinking about the future less abstract, text-based future scenarios still face the challenge of bridging the "experiential gulf" [18]. Here, experiential scenarios help to create embodied experiences about the future in order "to engage people more viscerally in futures conversations" [19]. Such embodied experiences might be created through scenarios using audiovisual narrations or tangible artifacts, such as design fictions and speculative designs.

In the field of design, design fiction and Speculative Critical Design (SCD) have been used as strategies to support thinking about the future. According to Auger, the materialization of future scenarios through narrative, artifacts, or a combination of both help to reflect about a possible future as well as to "critique current practice" [20]. From the perspective of the author, speculations about technological futures

require careful management to ensure audiences can build bridges with the current present and thus consider speculative design as a plausible future.

Examples of SCD focused on techno-monitoring can be found in Auger–Loizeau's *Audio Tooth Implant*[1], the Vital Signs objects created as part of the Material Beliefs project [21], and the eight bytes of body project [22]. This project speculates about a plausible future in which anxious parents conduct biometric monitoring of their children's lives. In recent years, artistic SCD projects focused on techno-monitoring practices, such as Bjørn Karmann's *Project Alias*, Bernhard Hopfengärnter's *Belief Systems*, and Hyphen-Labs's *NeuroSpeculative Afrofeminism*, have received international recognition. Other interactive installations and exhibitions using SCD to trigger questions about digital data and privacy include Ania Catherine and Dejha Ti's *On View* and *The Glass Room* by Tactical Tech and Mozilla. Beyond human techno-monitoring, prototypes have also speculated about the use of QS tools to support human–animal communication [23].

In recent years, SCD has gained recognition in the human–computer interaction community, bringing a critical understanding of human–technology relations [24]. Despite this positive reception, in technology-enhanced learning design, SCD has not been used as a strategy to foster critical debate among education stakeholders (to the best of my knowledge). The research reported in this text aims to address this gap by exploring the range of reflections triggered by an experiential scenario about a possible future around physiological techno-monitoring in learning and education using an SCD prototype. In line with the approach used in the Designing Policy Project [25], the adoption of a participatory design approach for ideating the prototype aimed to include stakeholder diversity, overcoming some of the limitations regarding diversity and privilege in SCD projects [26], [27], [28].

The following section reports a participatory SCD case about techno-monitoring in learning and education. As part of the case, I present a futures scenario and an SCD prototype named the Feeler along with a description of the participatory design process through which the scenario and prototype were created.

3 Design Case: Prototyping a Possible Future in Learning and Education

In this section, I present a critical design speculation on self-monitoring technology in learning and education using Ethnographic Experiential Futures (EXF). EXF is an approach to futures research proposed by Candy and Kornet that combines Ethnographic Futures Research (EFR) and experiential scenarios. According to the authors, "Ethnographic Experiential Futures is a design-driven, hybrid approach to foresight aimed at increasing the accessibility, variety and depth of available images of the future" [29].

[1]More information about this project can be found at: http://www.auger-loizeau.com/projects/toothimplant.

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EFR provides a socio-cultural lens to elicit and interpret people's images of possible and probable futures as well as their preferences among those visions [30]. The emphasis is less on prediction and more on exploring how people envision the future, with special attention to those preferable futures. EXF builds on EFR to generate experiential scenarios that create multisensory experiences related to possible and preferable futures. Such experiential scenarios are key to inquiry into people's views of what is regarded as possible and preferable in a particular context [31].

As part of this study, an experiential scenario integrating a prototype (Feeler) that monitors physiological data was developed to explore learners' preferred futures related to self-monitoring tools in learning and education. Next, I introduce the Feeler scenario and prototype and describe the participatory process for eliciting these.

3.1 Scenario and prototype

Based on current trends, various world forecasts (e.g., [32] and [33]) have projected that by 2030 the amount of people experiencing mental disorders will increase significantly. It has been estimated that depression will be the most common cause of disability. To counteract this trend, the 2030 Agenda for Sustainable Development has included mental health as a priority for global development [34].

As part of their efforts to meet global sustainable goals, higher education institutions have initiated campaigns promoting student well-being, encouraging them to develop skills to manage their academic work in a sustainable way. In addition to talks and mentoring services, higher education institutions make tools available for students to aid them during their independent study activity.

One of the initiatives to support student well-being consists of monitoring their physiological states. It is expected that by helping students gain awareness of physiological data, such as their levels of attention and relaxation when studying, they will be better prepared to self-regulate their activity. For this purpose, the university study center offers a tool, named the Feeler, that students can borrow for a period of time to self-monitor their mental states. Students borrowing the Feeler get the support of a study tutor, who introduces them to techno-monitoring and guides them to reflect on their experience using the Feeler.

The Feeler prototype is made of software and a set of external computing devices that guide learners' actions when interacting with the system during a study session (see Fig. 1). The Feeler set communicates with a self-monitoring helmet that collects data about the user's mental states. This information is captured by the helmet as electroencephalographic (EEG) data and translated into attention and relaxation levels. In addition, the Feeler software encourages users to gain awareness of their mental states by asking them to report how attentive and relaxed they were at various moments when using the prototype.

Feeler divides a study session into three key moments: before, during, and after the session. To start a session, learners need to set up the devices and log in to the software. Once the session starts, learners are asked to follow a script consisting of three phases: (1) meditation, (2) study, and (3) play. Each of these phases is

associated with a computing device that provides learners a tangible interface that gives them feedback to guide their actions.

Fig. 1. A student using the Feeler during a study session.

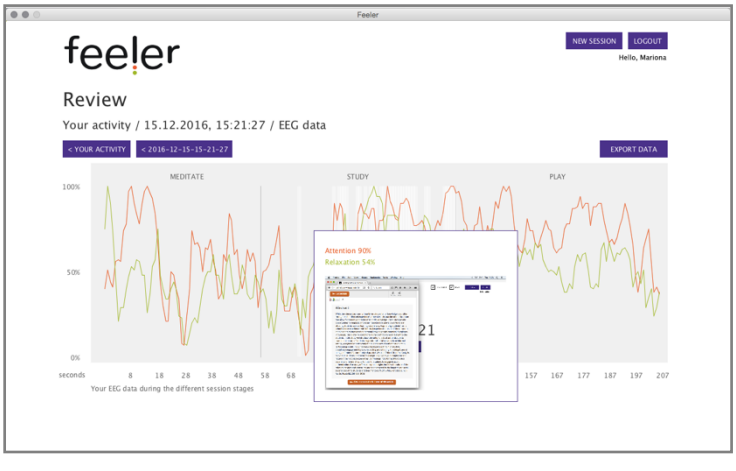

Fig. 2. Visualization of the learner's attention and relaxation levels relating the EEG data with the screen capture of the learner's digital activity.

During the meditation phase, learners engage in a calm breathing exercise for five minutes. The meditation device guides learners' breathing rhythm through visual feedback. Once the time is over, the pulsating light fades out, and the device vibrates. After meditating, learners conduct independent study work using their computer. The time set for this activity is 20 minutes. When learners' attention and relaxation levels

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surpass certain thresholds, the Feeler app takes a screenshot of their digital activity. The study device light grid illuminates as the time passes. Once 20 minutes have passed, the study box vibrates, and a version of the Simon electronic game activates in the third box. This game consists of repeating a sequence that increases one step every time learners repeat it correctly. The steps are displayed through lights and audio. When learners make a mistake, the Feeler app activates again, and they are invited to self-assess by rating their satisfaction level (satisfied, neutral, dissatisfied) and estimating how attentive or relaxed they were (in a scale from 0 to 100%) when meditating, studying, and playing. After submitting the self-assessment questionnaires, learners can examine the data from their last session as well as from previous ones in the Feeler app visual dashboard (see Fig. 2).

3.2 Process

The EXF process identifies four main phases: Map, Multiply, Mediate, and Mount. The process is described as circular, susceptible to iteration since the experiential scenarios generated might trigger additional views on possible futures [29].

The Map phase consists of identifying people's images about the future, focusing on the probable, the preferred, the non-preferred, and a combination of them. Identifying the stakeholders to work with and defining the ways in which the visions of the future would be elicited are key mapping tasks. In this study, as part of the process of creating a techno-monitoring experiential scenario in a learning context, rapid ethnography using participant observation, user interviews, and focus groups were conducted to explore the perceptions of diverse education stakeholders (see Table 1). During this phase, qualitative data on the participants' experiences were collected through cultural probes and a co-design game representing the journey that users of self-monitoring technologies undertake (see [35]). This work yielded insights on several key aspects, such as people's positive perceptions of self-monitoring, their appreciation of solutions that might help them cope with stress and anxiety, as well as managing time and balancing work and study with personal life.

Building on the findings from mapping, the work during the Multiply phase focuses on producing alternate images about the future that challenge or extend the current thinking. As Candy and Kornet note, this work can be done in collaboration with the research participants [29]. In the context of this research, a participatory approach was adopted through co-design workshops in which participants were invited to ideate tools that collect and visualize learners' data (see Fig.3). Many of the participants' ideas focused on monitoring and visualizing data about learners' sleep, study, and physical activity. During this phase, stories, scenarios, and personas were also produced to expand the range of views about the future of techno-monitoring in education contexts (see Table 1). The outputs of this phase helped to portray additional views about techno-monitoring futures, which included participants' concerns about data ownership and privacy as well as their interest in diversifying the types of data collected and the forms of self-monitoring aided by digital tools. For instance, most of the participants' prototypes focused on visualizing data such as activity type, duration, and feelings. When sharing their ideas with others, the participants emphasized the importance of recognizing users as owners of their

personal data, allowing them to create their own meanings, and avoiding assuming that they would be interested in sharing their data digitally through social media. These ideas had strong implications for the definition of the Feeler scenario and prototype. For example, based on the participants' inputs, the design of the Feeler does not analyze the data for the user or set goals or make recommendations. The participants' concerns about privacy motivated the decision to not include features for sharing users' data through social media by default. In addition, it was decided that data would be stored locally instead of on the cloud, as many services do.

Mediation refers to translating the ideas about the future produced during the Map and Multiply phases into material expressions that enable people to experience a particular view of the future through tangible, immersive, visual, or interactive representations. In the design case presented, the data collected through the co-design workshops was used to inform the creation of mock-ups and prototypes representing a particular vision of the future. As a result of this work, the critical speculative design prototype named Feeler was produced (see Table 1). The naming of the prototype was inspired by participants' emphasis on supporting awareness of "invisible data." The final name was selected by education stakeholders (students, educators and researchers) through voting.

The Feeler was a central element of an experiential scenario showcasing an extreme case of techno-monitoring in an education context (see the following sections for a description of the scenario and the prototype). Building on the information obtained during the Map and Multiply phases, the prototype collected data to help students reflect about their study activity and lifestyle. In this sense, the Feeler built on students' views regarding what a desirable future about techno-monitoring in education might look like.

After designing the experiential scenario, the next step is to Mount, making it possible for people (those taking part in the previous phases and/or others) to become immersed in the scenario. At this point, ensuring a plausible look and feel of the experiential scenario is key to allowing the participants to have an authentic experience of the hypothetical future presented. The extent to which the context of encountering the experiential scenario is scripted might vary, ranging from highly scripted situations to guerilla situations. In this phase, ensuring the Feeler prototype was functional and had the look and feel of existing Quantified Self products available in the market was important to enable participants to have a "real" experience of how a possible future might feel. For this, identifying a suitable situation in which the Feeler prototype could be used was fundamental to communicate to the participants that Feeler was part of a possible future (see Table 1). As part of the actions to advertise the Feeler, demo sessions were organized and a website presenting the product was produced, using a similar style and tone to commercial products with which students might already be familiar.

Finally, analyzing the scenario's impact on people is key for determining which futures might be considered possible and desirable. This phase can be considered as part of the iteration work (in fact, Candy and Kornet refer to this work as Map2 [29]). To capture the participants' reflections and reactions to the experiential scenario, methods like interviews and observations might be used. In the context of this study, two experiential scenarios using different versions of the Feeler prototype (v.1.0 and v.2.0) have been developed. In both cases, graduate students experienced the scenario

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and the tool. The feedback provided about version 1.0 informed the iteration work that materialized in the Feeler prototype v.2.0. For example, based on the feedback provided on Feeler v.2.0, the last box was transformed into a memory game. In this article, I share the results of the analysis of the experiential scenario using the Feeler v.2.0 critical speculative design. As indicated in the section describing the research, the participants' feedback on v.2.0 was collected through interviews (see Table 1). The next section presents and discusses the findings using a narrative approach.

Table 1. Description of the EXF process about techno-monitoring futures in learning and education.

Phase	Methods and Instruments
Map	Semi-structured interviews with students and subject experts (n=10). Field observations in physical education and learning environments. Literature review. Three focus groups with graduate students (n=15). Questionnaires shared with graduate students (n=15).
Multiply	Three participatory design workshops with graduate students (n=15). Design concepts. Proto-personas. Design scenarios and use cases. Three presentations and feedback sessions on design concepts and scenarios.
Mediate	Four mock-ups and two lightweight prototypes. Production of two functional prototypes (Feeler v.1.0 and v.2.0).
Mount	Feeler v.1.0 test with graduate students (n=6). Feeler v.2.0 tests with graduate students (n=6).

4 Research

4.1 Participant Recruitment and Setting

Six university graduate students agreed to take part in the experiential scenario using the Feeler prototype v.2.0. Participation was voluntary, and the students received information about the study and their rights as participants before providing informed consent. In the consent form, students agreed to use the Feeler for 30 minutes, once a week, for three consecutive weeks in a dedicated space for independent study at the university. During the sessions, the participants worked on their master's degree dissertations.

The participants had diverse countries of origin, were fluent in English, and they were between 25 and 33 years of age. Most of them were familiar with digital tools

for self-monitoring and reported high levels of motivation to work on their dissertations.

4.2 Data Collection and Analysis

This study follows a qualitative approach to study learners' experiences using techno-monitoring in their study work. Semi-structured interviews were conducted after each session. Each interview focused on the participants' immediate experience using the Feeler and lasted between 30 to 40 minutes. In addition to the individual interviews, the participants joined a focus group session one week after their last session using the Feeler. In these sessions, the participants shared their reflections on aspects connected to the role of techno-monitoring for self-knowledge, self-control, and behavior change as well as how much they trusted the data captured by the system. All the sessions were audio recorded and analyzed using a narrative inquiry approach [36].

In this analysis, the participants' narrations have been considered as stories to reflect upon [37], [38] which enable a deep understanding of the students' experiences with techno-monitoring in learning and education. The meaning-making processes in which learners engage when looking at the data captured by a monitoring tool such as the Feeler are regarded as stories that convey discourses about learning, monitoring, data and well-being. Following this view, in this study I have used narrative analysis as a sensitizing concept to explore the collective interpretations and constructions triggered by a speculative critical design artifact.

The data analysis process can be divided into two stages: first, a thematic analysis in which main themes are highlighted [39], and second, a process of narrative-building in which the participants' stories are examined in relation to broader discourses [40]. During the first stage, the participants' audio recordings (11.5 hours in total) were analyzed using qualitative analysis software (Atlas.ti, v. 8.1.3) to identify key themes. The identification of themes emphasized the "what" [39]. Thus, the focus was on recognizing key issues that were recurrent in the participants' stories. This process was conducted in collaboration with another researcher, who also coded the data independently. Each round of analysis was followed by a discussion of the coding disagreements. This process was repeated twice until the level of agreement was considered acceptable (intercoder agreement=.97).

During the second stage, I apply cuts in the data to map stories that connect with broader narratives, revealing "the discursive context within which participants' stories were enmeshed" [40]. Next, I introduce three stories generated through participants' interactions with the speculative critical design prototype and discuss them in relation to existing societal patterns of meaning.

4.3 Findings and Discussion

The stories I present here are not intended to be exhaustive. In fact, many other stories can be found in the participants' reflections. The ones shared in this text have been selected because they capture the complex and paradoxical relations that techno-

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monitoring practices in learning and education create. I feel that these stories reflect key critical speculations about techno-monitoring in learning and education.

Story 1. A Matter of Trust: Lived Experiences versus Automatically Generated Data . "The problem is, you know, what your perception of being relaxed and you being relaxed, your brain being relaxed seems to be different. So, that's where the gap is, you have to either trust the machine or trust your own instincts, you know. My instincts said that I was super stressed when I was playing the game, but the data said that I was super relaxed!" (participant 1, focus group interview).

When the participants accessed a session's visual dashboard, they saw a comparison between the data captured by the EEG device and their own impressions reported in the assessment questionnaire completed at the end of the session. Quite often, the feedback provided by the system differed from the participants' self-reports. These contradictions caused confusion and triggered participants' reflection on how the EEG data captured by the sensor were translated into attention and relaxation. For instance, the following quote summarizes the participants' confusion regarding the interpretation of the values: "What does it mean, what Feeler means by me feeling relaxed?" (participant 4, session 1). Moreover, the interrelation between the states labeled as attention and relaxation was not clear. As one of participants expressed, "sometimes [it] is quite difficult even to separate both of them [attention and relaxation] when doing a skilled activity (...), so just defining it, this is relaxation state, this is attention state entirely is quite a bit tricky" (participant 3, focus group interview).

Because the algorithms used by the helmet collecting the EEG data were closed, the participants were not able to understand how their attention and relaxation levels were calculated: "I found it very contradictory because I thought, maybe if I pay more attention, I would be more stressed, but in some instances, it was just the opposite. So, I'm not even sure how these two terms are even related to each other. It may be mutually dependent or not, so that's something that one can find out" (participant 1, focus group interview). Throughout the sessions, the participants engaged in a reverse engineering exercise in an attempt to deduce how the system worked.

While the participants' curiosity was high, for some of them the initial excitement gradually converted into skepticism. The opacity of the proprietary algorithms placed them in a paradoxical position since they were expected to believe in the data-based science behind the algorithms without the possibility to understand the process. Still, four of the participants trusted the results based on the EEG data: "I'm actually surprised with the relaxation thing, I perceived myself as being too tense when I was researching, but I realized that I was not that tense. I think it was actually positive to see it happening or see it being measured" (participant 3, session 2).

This story showcases some of the challenges and even paradoxical situations that learners face when dealing with automatically collected data records. The participants' reactions when interacting and reflecting on the speculative critical design prototype revealed issues related to agency and empowerment in techno-monitoring systems, such as the extent to which students have agency in the techno-monitoring systems implemented in education contexts and how students can become empowered in opaque systems that are based on proprietary algorithms.

Opaque or "black box" algorithms are frequently used in Information Technology (IT) systems deployed in diverse areas of society [41]. From a design and usability perspective, researchers have warned that failure to consider human aspects in IT systems might cause distrust, alienation, and even rejection by those who are expected to benefit from the tools [41], [42]. As presented in this story, the participants felt confused because they could not understand how the system defined and calculated their levels of attention and relaxation. For them, as for any user of the EEG proprietary algorithm used in the Feeler, it was not possible to know whether the sensor or the algorithms were introducing any bias. In education systems, algorithms are increasingly used for decision-making (e.g., in grading). As recent incidents involving algorithm-grading systems have shown, algorithm-based decision-making systems might support inequalities, as they are not free from biases [43], [44].

While the experiential scenario presented through the Feeler was in a hypothetical future (to the best of my knowledge, no formal education institution uses EEG sensors to monitor students' levels of attention and relaxation when studying on a regular basis), the questions and reflections expressed by the participants could be applied to other techno-monitoring practices, such as LA. In fact, students' dilemma regarding accepting the EEG data analysis over their own assessment of their levels of attention and relaxation during the session relates to studies questioning the use of LA in education, as they might foster student disempowerment by making them passive and dependent [45], [46], [47]. From this perspective, data collection practices in formal education need to be examined and problematized to assess the opportunities and risks such practices pose to students as well as to other education actors.

Story 2. Building Objective Truths through Data "It's [decrease of attention when switching tasks] raising interesting thoughts for me, about this for example, doing some continuous work for a long time (...). It is strange because I felt I had felt this first, or like I was addressing this consciously sometime during last year or two that it is good for me, for example, to read a book in a continuous manner for a few hours but (...) I do something so rarely continuously for few hours that I think it is crazy (...). So, I think that brings that more strongly. And now I feel like scientific data is baking it up" (participant 4, session 2).

For the participants, it was easy to accept the data readings that aligned with their own impressions, but they felt hesitant to reject some of the system readings. In fact, during the same interview the same participant said, "Is everyone so skeptical in the first session?" (participant 4, session 2).

Quantitative data were understood as scientific evidence. In some cases, the participants referred to the data as an entity with agency. The expression "the data said that I was…" (participant 1, focus group interview) exemplifies the aura of credibility that surrounded "scientific data," even if the participants had no means to assess the validity of such data. The implicit credibility attributed to the data led some participants to adjust their self-assessments to match the system calculations. The following quotes exemplify some of the participants' adjustment strategies: "I somehow kept in mind that the last time I was very far, so this time I decided to go lower with estimations (laughs)" (participant 4, session 2); "I learned from the previous data, the previous EEG data, (...) that what I think about how much I think I paid attention, actually I'm not paying that much attention" (participant 1, session 2).

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In the focus group interview, after using the Feeler for three weeks, the participants discussed some of the meanings attributed to technology and data from a critical perspective. “Because it is a technology and it has these data so it has this feeling of something very hard, like hard data and science and so on, but I feel it is ultimately not, at least from my experience so far, because there are these very basic questions that we were talking like what does it mean for the machine that's relaxation and attention? What does it mean for me?” (participant 4, focus group interview).

In this case, the story describes the participants’ struggles in dealing with data, which they understood as scientific evidence. While critics of the empiricist epistemology have warned that data are constructed, popular discourses presenting quantitative data as neutral still prevail [47]. As some authors have highlighted, it is possible to identify a cultural narrative around datafication characterizing these processes as objective, certain, and impartial, in opposition to subjective human judgments and biases [48].

The trend of datafication has also reached the education domain [49], [50]. In education, data collection practices and analytics are used to improve education system management, resulting in higher levels of accountability [50] as well as supporting adaptation and personalization informed by evidence [2], [51]. However, as several scholars have argued, the datafication of education systems has also introduced inequalities as well as intensified managerialism and dataveillance practices [47].

The word “dataveillance” alludes to the collection of information in the form of data [52]. Such data-based forms of surveillance have expanded as more digital data have been made available in different spheres of life [53]. As with self-monitoring devices like the Feeler, individuals might voluntarily engage in dataveillance practices [54]. Yet, individuals’ level of knowledge and consent about what data are collected and their uses might vary [55]. As portrayed in this story, the normalization of dataveillance as a cultural phenomenon makes it challenging for individuals to resist and be critical toward these practices.

Story 3. A Brave New World Based on Tecno-Monitoring “I thought that happiness it's also like a key part of well-being and that eventually that will help you to kind of, you know, be more productive” (participant 1, focus group interview).

A common selling proposition of products based on techno-monitoring is that they contribute to well-being, which is paired with efficiency and productivity. According to this premise, individuals need to engage in self-improvement to reach the desired level of well-being. While self-improvement was not mentioned when introducing the Feeler, the participants took for granted that this device would help them improve their productivity when doing academic work. As one participant expressed, “I would give it a couple of weeks to see if helps me improve at what I do” (participant 2, session 1).

Beyond techno-monitoring, the expectation for self-improvement has also become ingrained in formal education. As one participant recognized, using the Feeler connected with this expectation in a tacit way, even though there was an actual choice: “The game reminded me (…) of this kind of challenges in school that I thought: oh, I need to improve myself or I need to be very good at this kind of, you know, things. And then I thought: but I don't have to” (participant 4, session 1).

Resisting the logic of continuous improvement required taking a moment to think and decide what was really necessary.

Using time effectively and being productive were assumed as the correct approach, to the extent of feeling bad for "wasting" time. One participant synthesized his high levels of self-demand as follows: "I always keep myself on work, you know? I'm kind of a workaholic. When I don't work, I feel kind of guilty, you know, that I've wasted so much time" (participant 1, session 1). Through the data captured by the Feeler system, the participants were able to reconstruct the moments in which they felt more focused and productive: "I feel that today's session I was the most focused on the task and I was able to do it properly" (participant 2, session 3).

The pressure for efficiency was also transferred to the tool. Thus, any benefits derived from the use of the Feeler should happen quickly. "If it doesn't work in a couple of weeks, if I don't see any real shift for me, then I will stop using it" (participant 2, session 1). The pressure for immediate changes is part of the social discourses celebrating speed and productivity and is also prevalent in cognitive work. Even though the Feeler presented a speculative design scenario about a possible future, for some of the participants that future was already present, meaning that the values that were attributed to techno-monitoring practices with the Feeler can be easily related to the neoliberal paradigm.

In learning and education, neoliberal ideas materialize through evaluation, which allows comparison between learners. When using the Feeler, the participants wished to compare their data with others: "Are people also more attentive than relaxed?" (participant 4, session2). The participants' requests to know how others were doing were a strategy to interpret the data. After all, numbers without a context had little meaning.

This story describes how particular subjectivities are produced through techno-monitoring and datafication practices. The participants' assumptions and expectations regarding how Feeler would support their academic activity highlight particular modes of governing the self that align with the neoliberal agenda [56]. As several authors have argued, techno-monitoring might be considered part of neoliberal politics based on measurements in which ideals related to well-being and productivity are actively defined [57]. In this context, individuals are encouraged to develop an entrepreneurial understanding of self, linked with self-improvement and personal growth, that emphasizes emotional self-regulation [58]. In fact, as can be observed in user groups based on techno-monitoring such as the Quantified Self community, one of most common motivations for engaging in self-monitoring is self-optimization [65]. Whether people engage in techno-monitoring for self-optimization or for other purposes like self-exploration or self-discovery, self-monitoring with digital tools is usually a highly individualistic practice [60].

According to Bradbury, neoliberalism should be regarded as a social and cultural configuration that goes beyond the economic system. In formal education, studies have claimed that the cultivation of neoliberal subjectivities can be traced to schooling practices. [62]. Higher education is not exempt from discourses that foster individual gain and self-regulation, attributing to individuals the responsibility for their successes and failures, without questioning the socioeconomic systems of advantage and disadvantage in which universities and individuals are inscribed [63].

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While techno-monitoring might be regarded as an opportunity to support student well-being by helping them better manage their academic activity, it is challenging to disconnect techno-monitoring practices based on datafication from the neoliberal value system, as the stories show. Considering this, the adoption and implementation of techno-monitoring practices in formal education is a sensitive matter that requires public discussion and democratic participation by diverse stakeholders, especially those who are disadvantaged and socially excluded.

5 Conclusion

In this study, a SCD prototype has been created to support students' embodied experiences of a possible future in which physiological techno-monitoring is a regular practice in learning and education. Students' perceptions about this possible future have been captured in the form of stories, which have been discussed in connection with broader narratives.

While the stories presented in the article are not exhaustive, they synthesize reflections about students' agency and empowerment, the constructed nature of data and the normalization of dataveillance, as well as the reinforcement of neoliberal subjectivities in techno-monitoring practices. Considering the increasing datafication of formal education, I believe the adoption of speculative critical design has contributed to supporting critical reflection among students, teachers, and education stakeholders regarding the deployment of techno-monitoring in education.

The adoption of a participatory approach in the Feeler design process helped to identify students' imaginings about techno-monitoring and trigger rich and complex reflections through the SCD prototype. Using the students' views to inform the design of the experiential futures scenario and the prototype enabled the creation of a powerful possible future, which is simultaneously disturbing and attractive. It is worth highlighting that while the Feeler scenario and prototype portrayed what students initially considered as a desirable future, the stories presented in this study challenge and even contradict the anticipated impact of deploying techno-monitoring in education.

While further studies are needed, I would argue that the active participation of learners in the design process was critical for creating compelling experiences among the students who later used the SCD prototype. Considering the results of this study, I conclude that participatory SCD has great potential to support the democratic transformation of learning technology by triggering public debate around possible futures.

The next steps include the co-design of further SCD prototypes exploring alternative futures about techno-monitoring in teaching and learning. As part of the work toward the democratization of learning technologies, it is also necessary to engage designers and developers of learning technologies in the creation of experiential prototypes based on emerging technologies in education to trigger discussion about desirable futures in learning and education.

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