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MEDIA, TECHNOLOGY & LIFELONG LEARNING
www.seminar.net

ISSN: 1504-4831 Vol 17, No 2 (2021) https://doi.org/10.7577/seminar.4232

Towards a Closer Look at the Pipes and Joints of Educational Data Infrastructures. A Technogenetic Analysis of the Experience API

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Abstract

In recent years, scholars in the field of Critical Data Studies have turned attention to the infrastructures through which educational data is produced, processed, circulated, and consumed. While respective studies have rightly emphasized the social, cultural, political, and economic factors that are shaping these infrastructures, the technical dimension of these developments has remained largely unexplored. As a consequence, analyses are easily deemed irrelevant by technologists and designers engaged in educational datamining and learning analytics. This paper therefore aims to broaden the analytic scope

[1] This research has received partial funding from the Federal Ministry of Education and Research under grant agreement n° 16DHB2119. We have no conflicts of interest to disclose. Correspondence concerning this article should be addressed to Christoph Richter.

of Critical Data Studies in education and to engage more closely with the technical dimension of the emerging educational data infrastructures. Towards this end, the paper outlines a technogenetic account of (digital) infrastructures and standards, and provides a case study to illustrate how this account can be leveraged to unravel assumptions and perspectives implied in an educational technology standard such as the Experience API. The results of the case study indicate that while the Experience API is of highly abstract and generic nature, it promotes a rather restricted idea of learning and education.

Keywords: critical data studies, technogenesis, infrastructure, standards, xAPI

Towards a Closer Look at the Pipes and Joints of Educational Data Infrastructures

The focus of this paper lies on the digital infrastructures that undergird the current digitization and datafication of educational processes, and especially the technical standards and protocols on which current advancements in educational datamining and learning analytics are based.

With the more recent proliferation of Critical Data Studies in education, there has also emerged an increased interest in the infrastructures through which educational data is produced, processed, circulated, and consumed (e.g. Sellar, 2015; Selwyn, 2015; Hartong, 2018; Williamson, 2019). Drawing on conceptual models developed in the field of Science and Technology Studies, respective studies have shown that educational data infrastructures and analytic technologies that are hooked into these infrastructures are not mere technical devices but are intimately bound with social, cultural, political, and economic processes. Yet, while Critical Data Studies in education have rightly drawn attention to the practices, believes, and interests that shape and are shaped by these infrastructures, the distinct role of technology as such has remained quite shallow. In trying to reconstruct data infrastructures as relational “networks of objects (the data itself, hard- and software, but also policy ‘fragments’, such as educational standards or funding formulas) and subjects (technicians, administrators, school actors, intermediary agents, etc.)” (Hartong, 2018, p. 135), the inherently technical dimension of these infrastructures, the pipes and joints, remained in the background and escaped closer analysis. As a consequence, proponents of Critical Data Studies in education have been charged of not being able to provide “a more essentialist argument that data/analytics/AI infrastructures *necessarily* entail reductionist commitments” (Buckingham Shum, 2019, p. 8 in response to Selwyn, 2019). We therefore believe that there is a strong need for conceptual models of digital technologies and infrastructures that allows us to analyze them as historically and culturally contingent entities, as entities, which are neither fully accounted for by their designers’ intentions nor by their practical utilizations.

Against this background, the overall intent of this paper is to broaden the analytic scope of Critical Data Studies in education and to engage more closely with the technical dimension of the emerging educational data infrastructures. Towards this end, the aim of this paper is both to outline a technogenetic account of (digital) infrastructures and to show how such an account can be applied to the critical analysis of a standard in the field of educational technology. Combining a relational perspective on infrastructures with a genetic understanding of technical objects, we will identify technical standards as pivotal for a critical understanding of the processes of digitalization and datafication, as it is only through these standards that data can be effectively generated, passed, and processed. In particular, we will argue that from a technogenetic perspective, technical standards can ensure interoperability and scalability only to the extent that they reduce complexity and limit diversity, which in turn implies that respective choices have to be made and socially legitimized.

To illustrate that a technogenetic account is not only of theoretical interest but also opens up new empirical strands for Critical Data Studies in education, the main share of this paper is devoted to a case study on the Experience Application Programming Interface, or xAPI for short. xAPI is a specification that has been devised, quite generally speaking, to support the recording, exchange, and retrieval of data on learning processes across digital platforms. In providing a common format for the recording of respective events and interactions, xAPI can be understood as a technical standard for the description of educational processes. Consequently, xAPI has an impact on the kind of information that is rendered available and in turn can be used for the analysis, monitoring, and control of an educational environment. We have chosen xAPI as an example here because it constitutes one of the most recent steps in a longer chain of standardization efforts in the field of educational technology and is also key to many current efforts in educational data mining and learning analytics. Additionally, we, as a research team, were also directly engaged in the utilization of xAPI as part of an ongoing R&D-project, providing us with first-hand experiences of the challenges that come along with its implementation. We will use this case study to show that technical standards, regardless of how abstract or generic they appear to be, are culturally and historically contingent and hence necessarily imply socially and culturally impregnated understandings of the domains they are supposed to model.

On Infrastructures and Standards – a Technogenetic Perspective

To be able to trace the cultural and historical contingencies of (technical) standards in the processes of digitization and datafication in education, we combine a relational understanding of infrastructures and standards (e.g. Star & Ruhleder, 1996; Karasti et al., 2010; Mongili & Pellegrino, 2014) with a genetic perspective on the evolution of technical objects (e.g. Simondon, 2011; Rieder, 2020)[2].

A relational understanding: We start from the premise that *infrastructures* cannot be reduced to static networks of interconnected technical objects, but that they form complex and constantly evolving assemblages of devices, resources and human actors, that are deeply entwined with organized practices, habits of thought, subjectivities, and values (cf. Star & Ruhleder, 1996; Mongili & Pellegrino, 2014; Sellar, 2015; Shove, 2017). Rather than being “a thing with pre-given attributes frozen in time” (Star & Ruhleder, 1996, p. 112), infrastructures are fundamentally relational in that they “[emerge] for people in practice,

[2] While the terms digitization and datafication have been used to denote a historically formed array of social practices and linked to broader issues of epistemology, power, and inequality (e.g. Pangrazio & Sefton-Green, 2020; D’Ignazio & Klein, 2020; Daly et al., 2019), our focus in this paper is on the more mundane technical necessities, the bits, pieces, and procedures it actually takes to produce and use digital data.

connected to activities and structures" (ibid.). The relational nature of infrastructure thereby entails both the "convergence [of infrastructures] with human behavior and social practices" as well as the "embodiment of standards" (Mongili & Pellegrino, 2014, p. xxiv). Accordingly, standards are key to the formation of any kind of infrastructure, as they provide common and legitimized schemes and protocols that enable the interconnection and interoperation of heterogeneous components within an assemblage, and hence "allow the growth and cultivation of shared IIs [information infrastructures] and collaborative platforms" (ibid., p. xxvi).

The capacity of standards to scale an infrastructure and allow for "the articulation of 'the same' technology elsewhere" (ibid., p. xxvii), thereby essentially hinges on their capability "to screen out unlimited diversity". Their productive qualities hence depend on the extent to which they can effectively reduce complexity in a particular field of action. As a consequence, standards cannot be neutral, as due to their reductive nature, they inevitably "codify, embody, or prescribe ethics and values" (ibid, p. 5). As infrastructures are not self-entailed entities, but themselves relationally embedded in other assemblages, standards also do not exist in isolation but are nested, linked, and integrated with one another (ibid. p. 5 ff.). Due to the relational nature of infrastructures, standards are also not static entities, but temporally stabilized "points in a process of standardization" (Mongili & Pellegrino, 2014, p. xxvii). Even though their successful implementation adds to an infrastructure's 'interia', they are also under constant pressure caused by the ongoing utilization and transformation of the infrastructure itself. In this sense, standards can be understood as 'technical objects', that have an identity of their own while their relevance and meaning is simultaneously bound to the existence of a corresponding sociotechnical milieu (cf. Y. Hui, 2012; Rieder, 2020).

A technogenetic approach: The technogenesis of a standard is therefore recursively coupled both with the development of (technical) devices, in which the standard is embodied, as well as the practices that in turn make use of and give rise to the development of these devices. Based on such a relational perspective, the technogenesis of standards can be traced along (a) their evolution as distinct technical objects, (b) the processes by which standards are embodied in particular (technical) devices, as well as (c) the practical uptake and utilization of these devices. From this point of view, standards, devices, and educational practices are constitutively entangled.

Entry-Points for Critical Analysis

The conceptual model of standards as technical objects – as sketched in the previous section – not only opens up an analytic but also a critical take on processes through which digital data is produced. While the model posits that standardization is essential to the formation of infrastructures and hence constitutes a prerequisite for any kind of organized and networked social practice, it also points to the fact that any standard necessarily entails a reductive moment in that it 'screens out' certain aspects of life's flourishing diversity. Consequently, any standardized scheme, form, or protocol implies a normative commitment, that favors certain construals of the world and marginalizes other choices. These choices are seldomly made explicit, but are usually legitimized with an implicit reference to what Susan Star and Martha Lampland have described as a "master narrative, [...] a single voice that does not problematize diversity" (Star & Lampland, 2009, p. 22), and what Andrew Feenberg has called a "technical code" that defines "the object in strictly technical terms in accordance with the social meaning it has acquired" (Feenberg, 1999, p. 88). As these master narratives are integral to a community's tacit understandings of the world, they usually appear self-evident and remain unthematic. A core aim for the critical analysis of standards therefore would be to uncover their underlying narratives. However, as from a relational perspective "there is no position of exteriority from which to perform a critical analysis" (Piattoeva & Saari, 2020, p. 1), a critical analysis cannot provide an objective or even conclusive account of these narratives. This is the case not least because any such narrative is an illusionary entity that is enacted in manifold and changing ways. Rather, what a critical analysis can do is to show that in the processes of standardization choices are made constantly. These choices are historically, culturally, and technologically contingent and therefore could also be taken differently.

To get a hold of the narratives that govern a standard, such as the Experience API, it therefore seems advisable to trace the implicated choices. In line with the relational perspective on standards, respective choices can be located in relation (a) to the evolution of the standard as distinct technical object, (b) to the design of a particular (technical) device, or (c) to the processes in which the usage of these technologies converges with social practices. In the remainder of this paper, we will use xAPI as an example to illustrate how a critical analysis could proceed along these three lines of inquiry and how these might add up to a more integrative understanding of the aspects and options rendered (in-)visible by a standard. In particular, we will trace the (pre-)history of xAPI as a learning technology standard, delineate the steps of 'translation' (Vinck & Jeantet, 1995) required in the technical implementation of xAPI, and outline the educational scenarios that are informed by these technologies.

The Experience API and its History

As already briefly outlined in the introduction, the Experience API essentially provides a shared format for the description of events that might occur in the course of both formal and informal learning activities. Respective records, so-called xAPI activity statements, can be provided by any digital technology a learner is directly or indirectly interacting with and can be aggregated in learning record stores. From these, the records can be accessed for further processing. In a nutshell, xAPI is supposed to support (a) the collection of data on learning activities independent of a particular device or platform, (b) the recording of 'any learning experience' irrespective of whether it takes place in a formal or informal setting, (c) the exchange and storage of these records independent from the platforms on which these records have been produced, as well as (d) the creation of analytic tools that operate on these data for monitoring as well as predictive purposes (cf. Rustici Software, n.d.-d).

To be compliant with xAPI, all activity statements that are recorded and shared have to be "expressed in the form of 'actor verb object'" (Rustici Software, n.d.-e). Each activity statement hence essentially has to provide a description of a person or group who did something (actor), of what actually has been done (verb), as well as the entity the activity was directed at (object). A statement that follows this format would be for example: 'Anne (actor) viewed (verb) the tutorial video (object)'. If needed, an xAPI activity statement can also include information on the context in which an activity took place as well as its results. Furthermore, activity statements might include information on when an event occurred, when the record has been stored, and an authority asserting the correctness of the record (ADL, 2016).

While xAPI specifies a generic format for the structured recording of activities, it does not provide any particular vocabulary, but deliberately leaves it up to its users to define the detailed information required by an activity statement as well as respective vocabularies. These supplementary specifications, which are required for the practical utilization of xAPI are called 'recipes' (cf. Bakharia et al., 2016). As such, xAPI hence is a very versatile specification, that, according to its authors, is capable "to collect data about the wide range of experiences a person has (online and offline)" (Rustici Software, n.d.c).

Even though the Experience API is one of the more recent efforts in the field of Educational Technology Standards (cf. Griffiths, 2020), its origins date back to at least 2008, when a call for whitepapers for the advancement of the Sharable Content Object Reference Model (SCORM) was issued by the International Federation for Learning, Education, and Training Systems Interoperability (LETSI) (Rustici Software, n.d.-a). Following up on the submitted whitepapers, the Advanced Distributed Learning (ADL) Initiative, a government program of the US Department of Defense (DoD), started to explore into the possibilities of "standardized experience tracking" in 2010 and contracted Rustici Software to devise first drafts of xAPI. The outcomes of this effort, called Project Tin Can, where then taken up by a working group of the ADL, resulting in a first stable release of xAPI in 2013 (ADL, n.d.-a). xAPI has been approved as an internal standard by the DoD in 2017 and forms part of its emerging "Total Learning Architecture" (cf. ADL, n.d.-b). xAPI is currently also in the process of formal standardization by the Institute of Electrical and Electronics Engineers (IEEE LTSC, 2020).

Yet, the history of the xAPI is not only made up of a sequence of consecutive events but is also itself situated in an evolving sociotechnical milieu. In the following, we will sketch some of the paths of development that are intersecting in the advancement of xAPI. For the sake of simplicity, we will focus on those paths of development that are explicitly mentioned by the authors of xAPI themselves.

First of all, the work towards xAPI took place against the background of substantial changes in the ways educational technologies were envisaged, created and used. While previous learning technology standards had been designed with a strong focus on reusable contents and courses to be administered in Learning Management Systems, xAPI accounts for the diversification of educational technologies that emerged throughout the last two decades. These include, for example, the spread of collaborative, mobile, cloud-based, blended, and personal learning environments, which are often also used in combination rather than in isolation (cf. Rustici Software, n.d.d; Griffiths, 2020). Consequently, there has been an interest to think of educational technologies not as solitary entities, but as elements of an encompassing “learning services ecosystem” (ADL, n.d.-b).

Concurrently, there also have been noteworthy shifts in educational policies that started to affect educational practices in countries across the globe (cf. Biesta, 2006). In particular, learning has increasingly been framed as an ubiquitous and lifelong process, dissolving the boundaries between formal, non-formal and informal learning, between profit and non-profit institutions, as well as between teachers and students (e.g. Tuschling & Engemann, 2006; Loeckx, 2016). These shifts clearly resonate with xAPI’s ambition to “record any learning experience, including informal learning” (Rustici Software, n.d.d), and its prospect that learning is something that could potentially occur everywhere and as a result of various forms of interaction.

Along these lines, the development of xAPI is also shaped by the more recent proliferation of Learning Analytics and Data Driven Education, a development that itself follows up on the idea of evidence-based education and is backed up by both educational policies as well as technical advancements in fields such as educational data mining, adaptive systems, as well as machine learning (cf. Ferguson et al., 2016). Towards this end, xAPI provides an important means for the collection and aggregation of data from various sources, making them available for respective analytic technologies. In doing so, xAPI is supposed to allow for the tracking and guidance of individual learning processes, as well as the monitoring and assessment of respective programs (Rustici Software, n.d.d).

Furthermore, xAPI also builds on and implements other technical standards. In particular, xAPI follows the principles of Representational State Transfer (REST) to allow for the orchestration of distributed web services and adopts the JavaScript Object Notation (JSON) as a generic means for the encoding and exchange of data. Additionally, the general xAPI data format, i.e. the description of activities in the form of ‘actor verb object’, is directly based on the WC3 Activity Streams specification (W3C, 2017), which had been devised for syndication of activities in social web applications. To better suit the purposes of xAPI, the data format of the Activity Streams specification has been extended to cover also information on results and context of a learning activity (Bowe, 2013).

These paths of development of course neither exist in isolation nor did they directly enforce the actual formation of xAPI in any strong sense. They rather form parts of the sociotechnical milieu that mutually shapes and is shaped by xAPI.

Translations Required in the Implementation of xAPI

As such xAPI defines a structure of statements and certain datatypes to be used in these, but neither the content nor the details needed to implement it into an application. During the implementation, decisions have to be made on different levels, which partly build on one another. Each of these decisions implies choices that are contingent on the sociotechnical milieu in which the implementation and instantiation of xAPI is taking place.

In a first step it is mandatory to *define the vocabulary* to be used. While xAPI's structure requires, for example, the use of a 'verb' to describe a certain activity by a certain user, it does not provide a vocabulary on the verbs to be used. As outlined above, it is rather intended that communities of practice define their own vocabularies for their particular use case. These extensions of the standard are also referred to as 'recipes' (Bakharia et al., 2016). While xAPI provides the syntactic structure, the vocabularies can essentially be understood as a set of names and descriptions of the activities, which might occur while using an application. The verb 'viewed' might be defined as "indicates that the actor has viewed the object", as for example in the already mentioned Tin Can vocabulary. The vocabularies used might extend or implement a subset of existing vocabularies or be developed from scratch. While the definition of a vocabulary by a community of practice is intended, it might also be defined by a project team working on a specific application in an ad hoc manner, for instance because of constraints like development deadlines and production or customer needs.

During this step, those events that are deemed relevant for educational purposes in a particular context, have to be translated into a set of defined activities. These definitions are in turn used as operational accounts of the envisaged learning processes in a given environment. Conversely, all activities that are not explicitly defined in advance are hence necessarily excluded from data collection. xAPI will therefore only be able to represent the defined activities, whereas all other forms of interaction with a platform – including other learning activities, which will inevitably take place (cf. Blewett & Hugo, 2016) – will be non-existing in the produced data and will not be reconstructable during data analysis. As a consequence, all those interactions that are not foreseen or predefined are rendered invisible. This coincides with the notion of learning as a totally plannable and controllable process.

While not required by xAPI itself, the vocabulary has to be translated further and formalized into *technical definitions,* to serve as requirements and technical designs for the actual software development process (IEEE Computer Society, 1990, p. 67). Requirements have to be defined as conditions that must and therefore can be met by a software. This might lead into the pitfalls of attempts to make human constructs amenable to computers (cf. Friedman & Nissenbaum, 1996). To illustrate this using our previous example, the verb 'viewed' might be further translated into the formal definition "the object has been on the screen of the actor for 5 seconds". Even if we consider 5 seconds instead of 3 or 10 the perfect timing, this translation remains ambiguous: without eye-tracking it is fundamentally unknown if an actor in a certain interaction with a computer actively looks at an object even if it is on their screen.

During the *implementation,* requirements and technical designs have to be translated into source code to be compiled or interpreted. As requirements as such do not provide exhaustive details and might be met by different solutions (cf. Zamudio et al., 2017), granular decisions have to be made, which will shape the final product. Decisions during implementation tend to be implicit and might be more technically than educationally informed. For example, they might be shaped by the use of specific programming languages, tools and frameworks (cf. Schmidt 2008). For instance, to fulfill the requirements of the verb 'viewed', an application might have to check if (a) a certain part of a website is in the focus area of a web-browser, if (b) the browser has view-focus, if (c) the browser has mouse-focus and if (d) no other application overlaps the area for 5 seconds.

As the final product usually has to meet a variety of requirements, different implementation decisions might interfere and cause unintended side effects which affect the data that are produced. For example, in an early production version of the tool developed in our R&D-project, students were provided with an overview of changes made to a section of their working document and enabled to revert to a prior version if needed. To prevent changes to the document while it might be reverted, the developers decided to place this function inside the edit-mode which had to be left afterwards. This implementation decision led to a condition where each 'view-log' event in the produced data was framed by a 'started-edit' and a 'canceled-edit' event. As a consequence, an unexpectedly high number of 'canceled-edit' events in the dataset caused speculations about students' behaviors until we realized the implementation details. Architectural decisions might also affect the data produced, for example if the emitting of xAPI-calls is assigned to a web client JavaScript code, it might be modified or blocked by adBlockers.

As virtually every software does (cf. Rodríguez-Pérez et al., 2020), the final product will inevitably contain bugs, which might as well affect the data produced. The already mentioned platform, developed in our R&D project, contained a bug in the client code, which under certain conditions caused a loop of video-related play and pause events without any user interaction. As the bug got conspicuous due to an enormous amount of produced events, an investigation showed that this bug had, on a smaller scale, previously already interfered on a number of occasions. Without this one obviously conspicuous event, the flawed data would have never been identified.

During processing of the produced and aggregated data, further steps of translation have to be undertaken. Because of the potentially massive datasets which are produced due to the statement logic of xAPI, data processing requires complex tool chains to transform data to be able to answer more specific questions or address specific issues. Inherently, these translations bear the same limitations as outlined for the implementation.

(Some) Current Applications of xAPI

While xAPI so far is only actively used by a minority of practitioners that are making use of educational technologies (Torrance, 2019), and while it is also taken up rather slowly even in the field of learning analytics (e.g. Muslim et al., 2020), the specification has already been integrated into a broad variety of technical systems, applications and services (cf. Rustici Software, n.d.b). Besides its adoption by commercial vendors and service providers, xAPI is also used by a growing range of R&D projects and strategic initiatives in the field of learning analytics. As a comprehensive survey of all these efforts is beyond the scope of this paper, we can only roughly outline the spectrum of current endeavors. To do so, we will focus on some of the ways in which xAPI has been appropriated, the actors involved, and the educational scenarios envisaged.

As xAPI depends on technical means for the provision of activity statements, e-learning authoring tools constitute a key element for its adoption, as they allow for the integration of xAPI into the processes of educational content production. The basic idea here is to augment interactive digital contents, such as slides, videos, quizzes, test, etc., with the capability to directly record users' interactions and feed the resulting activity statements into a learning record store. The possibility to generate xAPI activity statements has already been integrated into quite a few common authoring tools (cf. Rustici Software, n.d.b), providing both professional content creators and educators with the technical means for the collection of data on users' interactions. The authoring tools, however, differ in the extent to which they support xAPI. While authoring tools that support xAPI usually provide a set of predefined activity statements, for example on whether a particular resource has been launched, a test has been passed, an activity completed or if a question has been answered (in-)correctly; several tools also allow for the creation and use of customized xAPI statements (cf. Schneider & Penn, 2019). In doing so, the tools enable content creators and teaching staff to create digital resources that can generate fine-grained traces of learners' interactions, for example, in that they not only record the submitted answer to a multiple-choice question but also the options selected before a final choice has been made.

At the same time, several R&D projects have set out to tap into data sources beyond those generated by traditional learning management systems or e-learning resources, and to instead devise new approaches to learning analytics that make use of and integrate multiple data sources. For example, the ›Connected Learning Analytics Toolkit‹ allows to track interactions across a variety of social media platforms such as YouTube, Facebook, Google+, Google Drive, Twitter, StackExchange, and WordPress, and to map the recorded events into a uniform format of xAPI activity statements (Kitto et al., 2015). In a similar manner, xAPI has been used as a common data format to integrate and analyze data from a variety of sources in the Learning Pulse Project (Di Mitri et al., 2017). Data sources in this case included biosensors providing heart rate and step count, automated recordings of the digital tools used by the participants, information on weather conditions obtained from an online service as well as students' self-reports recorded via a web app. To make these scenarios work, these projects also engaged in the systematic development or extension of existing xAPI recipes.

At the other end of the data processing chain, there is also a growing number of tools aimed at the analysis and utilization of the recorded activity statements. Many standalone learning record stores also include a data analytics engine, allowing its users, for example, to query, filter, aggregate and visualize the collected data (cf. Berking, 2016). The outcomes of these analyses can in turn be used for the creation of dashboards and reports. To make these tools more accessible not only for specialists but also for educational designers, administrators and teaching staff, vendors of these analytics engines are trying to ease the creation of charts and queries and/or provide users with predefined reporting templates. Other tools even go a step further and use the outcomes of these analyses to trigger further actions. For example, the OnTask tool makes it possible for instructors to define rules that trigger so called 'Personalized Learning Support Actions' (Pardo et al., 2018), based on the outcomes of the preceding analysis of the recorded data. Even though the analytic tools are technically indifferent to the data that is provided, meaningful results nevertheless require intimate knowledge of the data sources used. Yet, to the extent that the choices made in the implementation of the recording procedures often remain tacit and in-transparent, this knowledge is often missing, and decisions might be erroneous.

Finally, there are also initiatives and projects that have drawn on xAPI to deliberately build educational data infrastructures on a larger scale. An example of such an effort is the Joint Information Systems Committee's (JISC) initiative for the creation of an open learning analytics architecture (Sclater et al., 2015). This architecture is intended to allow universities and further education institutions in the UK to collect and analyze data about their students in a common format. Besides the overall architecture and the provision of a learning record warehouse, JISC has also developed tools to make the recorded data accessible for strategic decision making, the teaching staff as well as the students themselves (cf. JISC, n.d.). For this purpose, the JISC has also specified its own xAPI recipes (JISC, 2021).

While this overview is rather eclectic, it gives some idea of the multifarious assemblage of educational technologies, services, and scenarios that are already making use of xAPI. As indicated, the utilization of xAPI is not limited to particular stakeholders or settings but covers a broad range of educational and analytic scenarios.

xAPI and its Implied Conceptions of Learning and Education

In outlining the evolution of xAPI as a technical object, in pinpointing the translations required for its implementation, and in sketching the ways in which it has been adopted, we have tried to depict the multiple ways in which xAPI is entangled in ongoing processes of standardization and infrastructuring in the fields of educational technology and learning analytics. Drawing on the relational conception of standards that we are proposing in this paper, our discussion will not focus on any particular instantiation of xAPI, but on the underlying master narrative and how this favors certain construals of learning and education while marginalizing other conceptions. To unravel the underlying master narrative, we will scrutinize the implied ontological, epistemological, and axiological commitments.

While xAPI essentially suggests that the 'actor verb object' format would allow for a generic and unbiased description of all kinds of learning experiences, the format itself implies a strong commitment to a substantialist ontology. xAPI hence builds on the idea "that human beings and things [or in xAPI terms: actors and objects] – the social and the material – exist as separate and self-contained entities that interact and affect each other" (Cecez-Kecmanovic et al., 2014, p. 809). Even though the descriptive format might appear intuitively reasonable as it apparently follows the English syntax (cf. Kevan & Ryan, 2016), it is highly problematic as it presupposes that all relevant activities are essentially transitive in nature, i.e. that they can be properly described in terms of an identifiable subject that is acting upon a distinct object. As a consequence, the format marginalizes all those educational accounts that build on a relational ontology and which assume education and learning processes to be essentially intransitive in nature as actors and objects only come into being in relational transactions (e.g. Emirbayer, 1997; Fenwick & Edwards, 2013; Jornet & Roth, 2018). As argued by Baker (2000), formats such as xAPI are ill-suited to capture educational processes in which the proper unit of analysis is an exchange or relation rather than an individual action. Typical examples include processes of joint meaning making, negotiation and creative collaboration.

Apart from its ontological commitment, xAPI also implies that learning experiences can be described independently of their performative enactment. Towards this end, xAPI draws on a representational epistemology as it assumes that what essentially matters to processes of learning and education can effectively be encoded in a representational format. This idea has been articulated most succinctly by Aaron Silvers, a core advocate of xAPI, who argued that “[a]n activity is an abstraction of something that can be done (performed) by an individual” (Silvers, 2011). This claim is essential to xAPI as without such abstractions there would be no chance to record activity statements in a discrete and decontextualized manner. Furthermore, to set up respective systems, relevant descriptors need to be specified and implemented in advance, i.e. before some learning or educational activity is taking place. Or to put it differently, xAPI assumes that the conception, design, and analysis of an educational technology or setting, can be epistemically decoupled from the actual learning processes. However, such an epistemic account is limiting in at least two ways.

Firstly, it privileges descriptive accounts of educational technologies and settings over their concrete realization and therefore tends to ignore the productive translations that are required to make them practically operative (e.g. Vinck & Jeantet, 1995; Mackenzie, 2005).

Secondly, such an account is highly reductive as it limits learning and education to processes that operate in the realm of the already known and hence conceptually accessible. As a consequence, xAPI is not suitable to account for processes that are aimed not only at acquiring given knowledge or skills, but which are performative in that they reflexively challenge the adequacy of respective bodies of knowledge (e.g. Trede & McEwen, 2012) and approach learning itself as a formative and re/presentational practice (e.g. Osberg et al., 2008; Fenwick & Edwards, 2013).

Finally, from an axiological perspective, xAPI construes educational processes as goal-oriented activities. Educational processes are accordingly understood as means or steps towards a more or less clearly defined end. Again, Silvers puts this quite clearly when stating that “[g]oals are essential for motivation of the performance of any activity and when the goals are for the attainment of new knowledge then it is easy to see how activities become learning activities” (Silvers, 2011). Due to the fact that learning activities are assumed to be something that can deliberately be designed, this position assumes that the goals learning processes are oriented at, can or even are to be predefined as well. Accordingly, xAPI implies a largely instrumental and telic understanding of education, and therefore suggests an idea of learning and education as processes that are accessible to measures of regulation and optimization. This inclination towards a regulatory stance, that aims to attune learning to the attainment of extrinsic goals, is most evident in the ambitions to apply xAPI for predictive purposes (cf. Rustici Software, n.d.d). While such a regulatory agenda fits both reproductive and transformative pedagogies that derive their educational aims either from the status quo or a purported ideal state (cf. Ylimaki & Uljens, 2017), it cannot account for an ‘a-telic’ (Röttgers, 2015) or ‘non-affirmative’ (Benner, 1982) conception of education, which holds that respective processes are not a means towards an end, but that these are the processes in which new relations, orientations and ambitions are essentially formed.

In summary, xAPI nicely aligns with a broad spectrum of approaches and models both in education and industry. In particular, it suits approaches, which focus on the individual learner, assume that the most relevant knowledge can be represented effectively and adopt a regulatory agenda. By the same token, xAPI marginalizes all those approaches that construe learning as a deeply relational, performative and highly political process in itself. Accordingly, there is a touch of irony to the fact that while Silvers (2011) as well as Kevan and Ryan (2016) have argued that xAPI has been heavily inspired by activity theory, Engeström (2008, p. 258) insisted that "if activity theory is stripped of its historical analysis of contradictions of capitalism, the theory becomes either another management toolkit or another psychological approach without potential for radical transformations".

Conclusions

Our intent in this paper has been to add to the current discussion in the field of Critical Data Studies and Educational Science and draw attention to the ways in which standards are key to the formation of infrastructures on which educational technologies are operating. Using the Experience API as an example, we have aimed to show that despite standards being openly accessible and generic in nature, they are necessarily biased as they have to screen out certain perspectives and ideas on how the world could be understood and organized. We also do not think that the biases we have spotted in relation to xAPI are arbitrary. In fact, we believe that the master narrative that undergirds the most widely used educational technology standards has remained fairly stable throughout the last two decades (e.g. Allert et al., 2002; Wiley, 2003; Friesen, 2004). However, the aspirations of standardization initiatives became even stronger. Rather than 'simply' managing and exchanging contents, the declared ambition became to record all learning activities – whether occurring in formal or informal contexts – and to draw an even more comprehensive picture of what learners are actually doing. Even though educational technology standards might appear to be a boring or strange subject, we believe that they are an essential ingredient in the ongoing processes of digitization and datafication. As, from an infrastructural perspective, standardization is unavoidable, its analysis therefore might introduce us to "'[o]ther' ways of knowing", which in turn "can become important bridges that reflect back on 'our' ways of knowing" (Star & Lampland, 2009, p. 21). Neither the designs of educational technologies, nor the data structures and schemata these technologies are operating on, are normally defined from scratch, but implemented based on already existing frameworks and standards. Thus, the design of educational data infrastructures and platforms is intimately shaped by already existing educational standards such as xAPI. Yet, even though learners, teachers, and researchers are usually unaware not only of the standards as such but also the sociotechnical processes from which they emerge, they effectively impact the technologies we are using and the ideas of education we are pursuing. As such, educational technology standards are of high relevance for education and educational research.

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