Evaluation of Data Literacy Frameworks and a Self-Data Curriculum for High School Students

*Topic from Conference: *Curriculum: Curricula for global technical challenges*

Maria Jose Hernandez-Serrano
Theory and History of Education Department
University of Salamanca.
Salamanca, Spain
mjhs@usal.es

Girija Chatufale
Department of Psychology
New York University
New York, United States
girija.chatufale@nyu.edu

Felicia Zerwas
Department of Psychology
New York University
New York, United States
fz2338@nyu.edu

Xavier Ochoa
Department of Administration, Leadership and Technology
New York University
New York, United States
xavier.ochoa@nyu.edu

Camillia Matuk
Department of Administration, Leadership and Technology
New York University
New York, United States
cmatuk@nyu.edu

Suzanne Dikker
Department of Psychology
New York University
New York, United States
suzanne.dikker@nyu.edu

2024 21st International Conference on Information Technology Based Higher Education and Training (ITHET) | 979-8-3315-1663-5/24/$31.00 ©2024 IEEE | DOI: 10.1109/ITHET61869.2024.10837612

***Abstract*— With the emergence of self-tracking devices that collect and produce real-time personal data, it is becoming increasingly necessary to innovate data literacy frameworks and student curricula to address new competencies in data handling, visualization, and use. We examine the evolution of data literacy frameworks across the past 7 years, specifically focusing on the inclusion of self-data competencies. We analyzed existing data literacy frameworks to identify common phases of data engagement. A scoping review of published data literacy frameworks was conducted, and 23 studies were included for analysis. Results from this scoping review demonstrate the existence of at least eight sequential phases of data engagement to develop data literacy. Two of these phases address personal or self-data competencies. We then describe a curriculum that addresses these eight phases of data engagement by pairing biometric devices with online tools and educational materials to scaffold self-data knowledge, skills, and attitudes. Based on this, we conclude with the need to propose holistic data literacy education programmes, considering the curriculum as a model to guide similar materials aimed at fostering emerging data competencies.**

***Keywords*—** *Curriculum, Data Literacy, Middle School Students, High School Students, Quantified Self, Biometric Data.*

I. Introduction

Self-tracking devices and other digital technologies, such as smartwatches, FitBits, and Oura rings, are increasingly able to collect and produce real-time visualizations of personal data. Individuals are producing data that promote engagement in self-monitoring data [1] and possibilities to develop body awareness and body representations [2], as part of the Quantified Self movement [3].

Though the practice of self-recording, visualizing, and interpreting this real-time personal data has become widespread, translating this practice into a meaningful and critical understanding of data's role in our daily lives is not straightforward. Making data useful for individuals' interpretation requires certain abilities from users, and possibly some attention to how algorithms and data are making our digital selves [4]. Converting data into knowledge requires effective engagement with not only bio-sensing technologies and data-visualization tools but also appropriately-scaffolded activities, discussions, and reflections on ethical data usage and critical interpretation [5]. All of these abilities for engaging with data —including self-data— fall under the umbrella of data literacy.

II. Data Literacy And Competencies

Data Literacy (DL) involves skills for reading and working with data to solve problems or make decisions [6]. DL is more than Statistical Data Literacy. It involves not only the ability to analyze and interpret patterns and trends in data but also the ability to critically interpret and communicate about data, given its provenance, quality, and implications [7, 8].

Distinctively, although DL is also closely related to Data Science, the latter refers to more specialized scientific training within a data-related domain and specialty and thus differs in the level of technical competence achieved [9]. Meanwhile, DL refers to a broader set of foundational skills necessary to engage with, interpret, and make informed decisions about data, aiming to prepare not only data professionals but all learners to become citizens capable of making decisions based on understanding data. In this regard, the potential for DL is not only limited to more traditional data-related fields such as STEM education, data science, or statistics.

Developing students' DL is important for every student to be able to navigate the datafication of today's world [10], which means that the analysis and representations of our

979-8-3315-1663-5/24/$31.00 ©2024 IEEE

lives, captured through data recording devices, could be transferred and sold as a new form of value.

In the area of education, the introduction of DL is becoming prominent. International frameworks for the future of educational systems from OECD [11] and UNESCO [12] assert that students must be competent in managing data, and that teachers must be able to prepare their students to develop these and related competencies (such us browsing, searching and filtering data, managing digital identity, and protecting personal data). K-12 STEM (Science, Technology, Engineering and Mathematical) curricula and teachers from these areas have started to develop interest in DL as an opportunity for students to engage more deeply in scientific practices by improving their ability to think critically about data [13].

Recent education programs and curricula propose a more humanistic approach to DL [14, 15, 16], grounded in a framework that considers ethical, critical, and community impacts for data representation and transformation [17]. This new holistic approach demands the development and teaching of new data skills and practices [18, 19] revisiting.

More importantly, self-tracking activities are challenging a new perspective in DL. It is critical for data literacy learning goals to evolve and include emerging competencies with self-generated data. These competencies would involve abilities to critically engage with biometric and neurotechnologies: knowing how data generated from these technologies are collected, managed, analyzed, and protected; and how to reason critically about their own data.

According to such emerging competencies, and the requirements for an evolution of the DL area, the focus of this paper is twofold: First, we analyze existing data literacy frameworks to identify how they align with sequential phases of data engagement (i.e., accessing, managing, analysis, etc.) and whether there is emerging interest in self-data and data self-tracking visualization and interpretation; and second, we offer an example of how DL phases can be supported by describing a novel curriculum centered on students' engagement with personal biometric data.

III. Method And Procedure

To address the first aim of this study, we conducted a scoping review of published DL frameworks, and analyzed these frameworks to identify: a) the types of technical data skills and phases of data engagement most frequently included; b) the social knowledge, skills, and attitudes addressed in the data literacy frameworks; and c) the inclusion of personal or self-data within the frameworks. This analysis and its resulting categories serve the second aim of the study: using these categories to present a comprehensive curriculum for engaging high school students with self-data.

The analysis of data literacy frameworks used the PRISMA method [20], and was carried out in June 2024, via the Scopus database, using the search string:

["data literac" OR "data education" AND (framework OR matrix OR curriculum OR field) AND (competenc* OR skills) AND (teach* OR educator*) OR student*]*

Exclusion and inclusion criteria based on the research aims were:

- Availability: full-text, English or Spanish language (the primary languages of this study's authors), last 7 years (2017-2024).
- The study is a framework, a curriculum or a lesson/s on data literacy, framed by a humanistic view of data literacy for students in all educational levels or wider citizenships.
- The study includes a description of identifiable phases for data engagement.
- The study includes types of knowledge, skills, attitudes or behaviors on data literacy.

The PRISMA flowchart illustrates the process (see Figure 1).

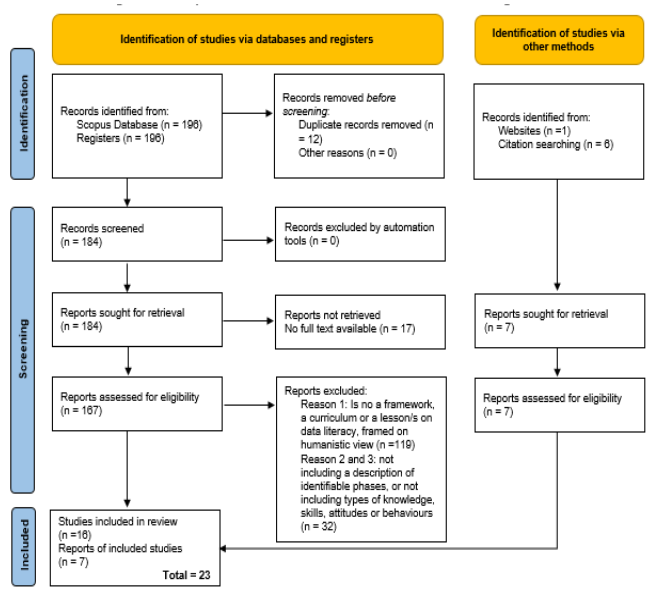

Fig. 1. PRISMA flow diagram, Scopus DataBase (*June 2024*)

This PRISMA diagram shows that from the 196 papers returned in the search, 12 were removed before screening due to having been published by the same authors presenting same studies (e.g., one as a conference paper, the other as a journal article based on the conference paper), in that case, we considered the one most recently published. The remaining 184 papers were found to have reported on data literacy for screening. From them, 17 were excluded due to the full text not being accessible; 119 for not presenting a framework or curriculum on DL; and 32 were excluded because either no information was available on data engagement phases or no information was described on the type of knowledge, skills, attitudes or behaviors related to DL competencies. The remaining 16 studies were included for analysis. Additionally, during the eligibility process, some studies referred to other innovative DL frameworks that met the inclusion criteria (1 website and 6 European projects' reports), hence 7 additional studies were added from this second method. In total, 23

frameworks were selected for inclusion in the current study for the analysis.

IV. RESULTS

From the analysis of the selected DL frameworks, we first examined the type of publication (see Fig. 2 left), and found that Journals were the more frequent type (40%) and conference papers (30%); other resources analyzed included books, project reports, and a project webpage. There was variability in the year of publication (see Fig. 2 right) with more studies for the years 2021 and 2024.

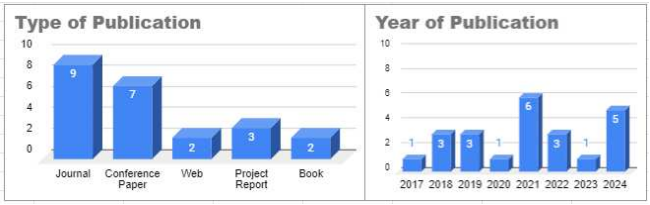

Fig. 2. Analysis of type of publication (left) and year (right)

Regarding the target audience, from the 23 frameworks analyzed, most frameworks consider students as principal recipients (13 out of 23), with references to teachers, educators, and trainers but also librarians [23] as responsible for training the students on DL, either in-person or online. According to Figure 3, 4 (17%) frameworks refer to citizens as a general target audience [27, 34, 31, 40] and the rest refer to different levels of education. Specifically, ten frameworks refer to secondary/high school level and nine refer to higher education/university level, of which first-year students were considered for inclusion in this study.

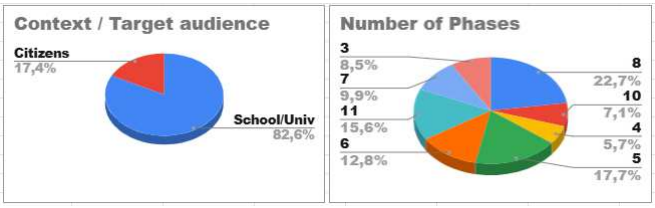

Fig. 3. Analysis of target groups (left) and number of phases (right)

The secondary/high-school level frameworks varied in terms of target audience and content area; only one was specific for middle school [37] and another for vocational education and training [24]. Four of these frameworks target teachers, educators, or trainers [24, 25, 29, 42], the first two for science discipline teachers and the last two for general knowledge discipline teachers. The other six frameworks for students target general knowledge application disciplines [22, 30, 38, 42] and the other two frameworks refer to science disciplines [26, 39].

Of the nine frameworks for higher education or university level, all are aimed at students or students and lecturers [35, 36]; of these, three are specific to data or information science students, biology students [32], computer science students [33] and other applied science students [35], while another three refer to general areas underpinning DL competencies for all disciplines [23, 28, 36].

The next phase of analysis focused on the number of phases for data engagement. Here, we identify and count the number of different phases presented in the DL frameworks. As depicted in Fig. 3 (right) we obtained a lot of variability, from 3 to 11 phases for working with data. These differences refer to the names used to describe the differential phases; while a great number of studies refer to 'areas' [22, 23, 25, 26, 29, 30, 39, 40, 41, 43], some studies used the term 'dimension' [28, 29, 34, 35, 36], and others considered 'domains' [27, 43], 'elements' [31], or 'steps' [21]. The differences between the phases are important for considering what kind of competencies are included, and how many distinctions within the frameworks require different competencies –either technical, reflective, or knowledge-based.

We then used inductive analysis to classify and differentiate the phases within the frameworks. This analysis provides evidence for at least eight sequential phases of data engagement to build literacy:

1) Meta-understanding of data: refers to an initial phase related to understanding what data are, where they come from, and for what purposes data are to be accessed or used, formulating ideas, problem definitions or hypotheses to work with data for different purposes.

2) Data preparation: refers to the planning required to determine what steps will be needed to obtain data that could be created (self-data recording), retrieved/collected from existing data-files, or found from several resources. In contrast to the previous reflective phase, this second phase is more operational.

3) Data work: this and the next phase overlap in some frameworks Some frameworks include a specific phase of data management and cleansing to verify quality before any further work, and refer to data organisation and storage to ensure privacy.

4) Data exploration: involves exploring, manipulating, creating, mapping and making visualizations, which requires critical considerations of the purposes of (mis)representation and abilities for creative design.

5) Data analysis/interpretation: with abilities to analyze, interpret, explain, compare, deduct, predict, infer, reflect, and/or critical thinking about working data.

6) Presentation and sharing of data: this phase refers to the application of strategies for (re)presentation, sharing, communication or showcasing data to different audiences.

7) Use and translation of data into information: involves decision-making from a process of applying, extending, realizing, transferring, translating, modeling, arguing, and/or concluding.

8) Data activism and advocacy: encompasses actions that build on the previous phase, with a critical transformative aim, from outreach to awareness raising or data-activism for political, economical, ethical or societal data reflexivity.

With the eight phases, we re-classified the frameworks in order to identify frequencies that might indicate which competencies are more or less related to DL. Table I shows the phases in columns, with the studies displayed by rows,

from 2017-2024, marking whether each framework describes the competencies for any of the phases.

TABLE I. COMPARISON OF ANALYZED DL FRAMEWORKS

			Identification of phases for data engagement							
Study	Year	Level	1	2	3	4	5	6	7	8
[21]	2017	University	*	*	*	*	*	*	*	
[22]	2018	HighSchool	*	*	*	*	*	*	*	
[23]	2018	University	*	*	*	*	*	*		
[24	2018	HighSchool	*	*	*		*	*	*	*
[25]	2019	HighSchool	*		*		*	*		
[26]	2019	HighSchool			*	*	*	*	*	*
[27]	2019	Citizens	*	*	*		*		*	*
[28]	2020	University	*	*	*	*	*	*	*	*
[29]	2021	HighSchool		*		*	*			*
[30]	2021	HighSchool		*	*	*	*	*	*	
[31]	2021	Citizens	*		*		*		*	
[32]	2021	University	*		*	*	*	*		
[33]	2021	University	*	*	*	*	*		*	
[34	2021	Citizens	*	*	*	*	*	*	*	*
[35]	2022	University		*	*	*		*	*	*
[36]	2022	University		*	*	*	*		*	
[37]	2022	HighSchool	*	*		*	*	*	*	
[38]	2023	HighSchool	*	*		*	*	*	*	*
[39]	2024	HighSchool	*	*		*	*	*	*	
[40]	2024	Citizens	*	*	*			*	*	*
[41]	2024	University	*	*		*	*	*		
[42]	2024	HighSchool	*	*	*	*	*	*	*	
[43]	2024	HighSchool	*	*	*	*	*	*		
		Count	**18**	**19**	**18**	**18**	**21**	**18**	**17**	**9**

With the 8 phases, we re-classified the frameworks in order to identify frequencies that might indicate which competencies are more or less related to DL. Table I shows the 8 phases in the columns, with the studies displayed by rows, from 2017-2024, marking whether each framework describes the competencies for any of the phases.

This comparison revealed variability in the number of phases in each framework, from 4 to 8; among the 23 frameworks analyzed, only two included all phases [28, 34], and it was common that the frameworks from the last years, targeting general citizens, made an explicit reference to critical literacy with the inclusion of phase eight [34, 40]; this is evidence of a shift towards more critical and community perspectives for data activism and data advocacy. The phase that was included more often was 'data analysis/interpretation' (phase five) in 21 of the 23 frameworks analyzed, followed by 'data preparation' included in 19. And the lowest frequency was for phase eight.

Considering the initial aims of the study, for aim a) *analysis of phases of data engagement,* we found that the frameworks emphasized technical data skills for preparation (phase two) and analysis and interpretation (phase five), however the rest of the phases were also highly identified, with the exception of phase eight on activism and data advocacy.

From an in-depth analysis, regarding aim b) *the social knowledge, skills, and attitudes addressed in the data literacy frameworks*, we found that DL frameworks focus primarily on types of data skills, and less on content knowledge or attitudes toward data. Ethical attitudes toward data interpretation, use, and protection are presented in 20 frameworks, either as a separate phase or integrated within several/all phases. In this sense, two of the frameworks for educators develop in detail objectives and activities: [24] that is a course with nine modules and [36] that is an open massive course (MOOC) with several lessons.

Finally, regarding aim c) *inclusion of personal or self-data*, only two of the frameworks selected for review addressed personal or self-data competencies [27, 29].

The first is "Personal Data Literacies" [27] which is a framework developed from critical perspectives and approaches of working with and managing digital data. With technical, social and ethical dimensions, it aims to develop critical reflexivity regarding the implications of data profiling and data recirculation. It aims to develop greater agency on the part of individuals so they make informed decisions about their data practices. This framework targets citizens, with references to individuals or users in general. The authors stated two possible areas of application for this framework: public education (formal and informal) and academic research.

The other framework including self-data competencies, from the DETECT project [29], targets secondary school teachers in developing their own and their students' critical digital literacies. From the digital literacy dimensions, sub-dimensions include exploring data analytics, understanding privacy and data security, using big and open data, and visualizing data. This framework identifies a number of new and emerging dimensions and sub-dimensions that have so far been overlooked by policymakers and provides an opportunity for educators to think carefully about the implications of these new areas for their approach to education in their local contexts.

Both frameworks refer to personal data in general, making mentions of digital behavior and data traces, considering self-

tracking information and social media data. Both also refer to the critical perspective around data, by including diverse areas of practice. Only [29] recommends activities in school, such as: understanding what algorithms mean and how they are used in recommender systems; protecting our data, including proactive decisions about not using particular applications or websites; understanding that data visualization might have an impact on human attention and behavior and can be the object of reading and deconstruction across educational activities.

These two DL frameworks included references to self-data competencies in several of the eight phases that emerged in the scoping review, which are elaborated on in Table II.

TABLE II. COMPARISON OF DL FRAMEWORKS ON SELF-DATA

Phase	DL Frameworks referencing self-data competencies	
	[27]	[29]
1	Identification of personal data and their type	-
2	Identifying how and where personal data are generated and processed	Develop sense of agency on own data use (proactive decisions).
3	Understanding the implications of managing, controlling and applying personal data	
4	-	-
5	Analyzing and evaluating the profiling and predictions that are made from processed personal data	Aware of the control, personalized and automatic recommendations or digital interaction surveillance impacts.
6	-	-
7	Applying the information that are represented by processed data (personal insights into digital self and performance)	-
8	Employing tactics of resistance and obfuscation Repurposing data for personal and social reasons	Aware of user generated data trace, collection and storage upon their digital interactions. Civic engagement beyond the actual opportunities of less educated collectives.

Specifically, Table II shows that phases one, two and three in both frameworks included attitudinal actions to make users aware of the implications and misuses of their own data use, as a preventative measure. In relation to the phase five 'data analysis and interpretation', both studies again reported preventative attitudes for users' awareness of wrong predictions and failures in data control. And regarding the last two phases, 'Use' and 'Activism', both frameworks consider insights into how data is affected their idea of self (identity) and how to make others aware of self-data -particularly those less educated about data- reinforcing the idea that the lack of DL poses some ethical challenges that demands civic engagement.

No references were found in relation to phases four and six, concerning exploring, presenting, and sharing self-data. This is important if we accept that skills in mapping or representing data also require attitudes to avoid misrepresentation of self-data.

V. TOWARDS A COMPREHENSIVE DL CURRICULUM INCLUDING SELF DATA

The analysis of DL frameworks can serve to evaluate new studies and frameworks in light of the phases evidenced, and the attention given to different competencies. As well, the analysis of how frameworks refer to self-data can be used to identify what kind of attitudes need to be considered for DL. We use these trends found in the literature to inform the creation of 'You: Quantified' [44] a 10-lesson curriculum designed to engage middle- and high-school students in exploring data generated by their own brains, bodies, and behaviors.

Through hands-on lessons, students are introduced to the basic principles of self-data, creative data visualization, and data ethics. Students are guided to work with biosensing devices and web-based creative coding tools to develop their own representations of their brainwaves, heart rate, sweat, movement, voice, and more. Through student-led curiosity-driven data explorations, students are prompted to think critically about the role that self-generated data plays in their daily lives, contextualize their observations within population-wide patterns, and connect with professionals who work with human data, to spark their interest in STEM careers. Each of the 10 modules follows the unit plan (see Fig. 4) and each lesson is divided into four sections: Explore, Learn, Create, and Apply. Each module discusses a separate data source (e.g., brain, heart rate, voice, video, movement) in the context of meaningful exploration (e.g., attention in the brain, heart rate variability and mental states). The first half of the course is focused on student-led explorations of different datastreams (e.g., brain, heart rate, face and voice) (in Fig. 4 see the blue content), while the second half of the course focuses on contextualizing this knowledge in the real-world, discussing ethical questions, and developing a final project (in Fig. 4 see the yellow content).

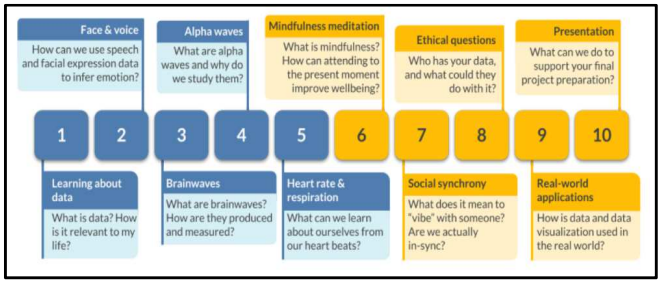

Fig. 4. You:Quantified unit Plan.

Curricular units provide instructors and students with the knowledge needed to record, process, understand, and represent brain/body data, and to appreciate the complexity of using and sharing this data in our current societal structures. Activities include interactive lectures, whole class and small group discussions, hands-on workshops with biosensors, guided exercises to engage with sandbox data

and sample code, and scaffolds to support students in ideating and conducting their own projects. Here, we describe how this curriculum addresses the identified phases of data engagement with a focus on knowledge, skills and attitudes related to self-data (see Table III).

TABLE III. COMPREHENSIVE SELF-DL FRAMEWORK

Phase	You:Quantified Self-Data Competencies
1	Understand the kinds of questions that can be answered with brain/body data
2	(recording data) Understand the biological processes that produce brain/body signals and the sensors used to measure data.
3	Distinguish between noise and variation within population-level data.
4	Learn how and why to combine brain/body data with behavioral data. Use and critique design choices to convey a data-based message.
5	Be exposed to various ways of representing brain/body data. Reflect on the connection between representation and interpretation.
6	Use representational strategies to effectively convey ideas to an external audience. Become familiar with data privacy protocols related to the purpose, accuracy, use, security, openness, and access to data.
7	Apply biosensing concepts and tools to conceptualize and develop a project. Develop data-based arguments.
8	Understand the potential ethical issues with collecting neurophysiological data. Understand one's ethical responsibilities in collecting and using data.

As an example, we will use *Lesson 3: Brainwaves* to describe competencies in the three learning domains of knowledge, technical skills, and reflective attitudes that learners can obtain through program participation. This lesson introduces students to brainwaves, and the use of neurotechnologies to record, visualize and manipulate their own brainwaves:

- Knowledge: Understand the biological processes that produce brain/body signals and the sensors used to measure them.
- Skills: Engage in brainwaves production (frequency, amplitude/power) measurement, and visualization.
- Attitudes: Be aware of individual variation and differences between artifacts signals and noise in data.

The aim of this description was to offer it as a model for a self-data literacy framework to guide similar curriculum design efforts, and to promote emerging data literacies for effective engagement with digital data and data-driven tools.

VI. CONCLUDING REMARKS FOR THE DL EVOLUTION

DL is an emerging area, yet with an unclear definition of core competencies that can be widely accepted across different fields [45]. The literature on data literacy has grown in the last years, at all levels of education and in all disciplines, mainly related to science education and statistics, with new intersections from media and civic education. The scoping review from this study found how the DL frameworks that aimed at general citizens, and from the field of media and communication, offered a necessary focus on critical understandings of the language, audience and representations of data, as stated by other studies [46]. This critical perspective is extremely important when working with personal data, which involves the need for users to be identified and interpreted themselves in real contexts [27]; and for being aware of impacts when their data is translated into automatic recommendations and dashboards, with real implications for their lives [29].

It is noteworthy that most of the DL frameworks analyzed focus mainly on technical skills and, to a lesser extent, critical attitudes or ethical considerations. Future frameworks and curricula should pay more attention to attitudes, as data ethics will play an increasingly important role in 'thinking ahead' [28]. From the frameworks that included ethics, we observed that it was in relation to the last phases, mainly for data use, with some nuances that remain that ethics and privacy are transversal competencies [40]. Thus, as a remark for future proposals, ethical principles should be included in each of the data engagement phases. According to a recent review of the most commonly found ethical principles [47], awareness of user autonomy and privacy can be included in the data preparation, work and use phases, raising awareness of the need to inform users about how their data are collected, processed and protected. Any data-led activity should also consider the final phase of data activism, using data to raise awareness or solve social problems, as well as increasing the data literacy of others, particularly those with less literacy opportunities.

Another remark concerns the interactions between phases and competencies. Most of the frameworks analyzed were characterized in the form of an iterative inquiry cycle in domains or areas, as other studies used terms such as 'datalife cycle' [45]. This is key to the effective development of DL in school contexts, as iteration requires a progression of levels of competencies and teacher scaffolding from one data phase to another, with fluid transitions and recognition of overlaps between phases.

Finally, in order to expand students' data skills toward self-data, educators can refer to different competencies, and use the eight phases found in this study. The model described from 'You: Quantified' is an opportunity for DL evolution on the collection and use of self-data and the potentialities of self-tracking devices for students' data engagement. Since the rise of self-tracking devices presents an opportunity for us to meaningfully engage with recordings and visualizations of our self-generated data, future curricula or frameworks may use the phases and the structure of knowledge, skills and attitudes for the design and development of flexible and comprehensive DL actions to cope with the era of datafication.

ACKNOWLEDGMENT

This study has been developed under a Fulbright Grant, United States Department of State, Bureau of Educational and Cultural Affairs and administered by the Institute of International Education (IIE). Reference: PRX22/00477.

This study was partially funded by the National Science Foundation (Award No. 2300780).

REFERENCES

[1] D. Lupton, "The diverse domains of quantified selves: self-tracking modes and dataveillance," Economy and Society, vol. 45(1), 2016, pp. 101-122.

[2] A. Boldi, A. Silacci, M.O., Boldi, M. Cherubini, M., Caon, N., Zufferey, N., ... and Rapp, A. "Exploring the impact of commercial wearable activity trackers on body awareness and body representations: A mixed-methods study on self-tracking," Computers in Human Behavior, vol. 151, 2024, 108036.

[3] V. R. Lee. "What's happening in the "Quantified Self" movement?," ICLS 2014 proceedings, 2014, p. 1032.

[4] J. Cheney-Lippold. We are data: Algorithms and the making of our digital selves. New York University Press, 2017.

[5] N. Berg. Ethical Reflections on Quantified Self Devices and their Effects on Humans. 2019. Doctoral dissertation, Hochschule für angewandte Wissenschaften Hamburg.

[6] J. Morrow. Be data literate: The data literacy skills everyone needs to succeed. Kogan Page Publishers, 2021.

[7] E. R. Martin, "What is Data Literacy?," Journal of eScience Librarianship;, vol. 3(1), 2014, e1069. https://doi.org/10.7191/jeslib.2014.1069

[8] M. Frank, J., Walker, J., Attard, and A., Tygel. Data Literacy: what is it and how can we make it happen? Editorial. The Journal of Community Informatics, 12(3), 2016, pp. 4-8. www.ci-journal.net/index.php/ciej/article/view/1347

[9] A.Y. Pedersen, and F. Caviglia. Data literacy as a compound competence. In Digital science. 2019. pp. 166-173. Springer International Publishing.

[10] J. E. Raffaghelli. Educators' data literacy. Learning to Live with Datafication: Educational Case Studies and Initiatives from Across the World, 2022.

[11] PISA 2025 Learning in the Digital World Framework (2nd draft). Available at: https://www.oecd.org/media/oecdorg/satellitesites/pisa/PISA%202025%20Learning%20in%20the%20Digital%20World%20Assessment%20Framework%20-%20Second%20Draft.pdf

[12] UNESCO. A Global Framework of Reference on Digital Literacy Skills for Indicator 4.4.2. 2018. Available at: ip51-global-framework-reference-digital-literacy-skills-2018-en.pdf

[13] J. Sickler, E, Bardar, and Kochevar, R. E, "Measuring data skills in undergraduate student work: Development of a scoring rubric," Journal of College Science Teaching, vol. 50 (4), 2021, pp. 44-51.

[14] V. R., Lee, M. H., Wilkerson, and K. Lanouette, "A call for a humanistic stance toward K–12 data science education," Educational Researcher, vol. 50(9), 2021, pp. 664-672.

[15] C. Matuk, K., DesPortes, A., Amato, R., Vacca, M., Silander, P. J., Woods, and M. Tes, "Tensions and synergies in arts-integrated data literacy instruction: Reflections on four classroom implementations," British Journal of Educational Technology, vol 53(5), 2022, pp. 1159-1178.

[16] C. Matuk, R. Vacca, A., Amato, M., Silander, K., DesPortes, P. J., Woods, and M. Tes, "Promoting students' informal inferential reasoning through arts-integrated data literacy education," Information and Learning Sciences, vol. 125(3/4), 20024, pp. 163-189.

[17] H. Gibson, M. E. Short, and C. O'Donnell, "Data, discourse, and development: Building a sustainable world through education and science communication," Frontiers in Communication, vol. 8, 2023, 981988.

[18] B. Ghodoosi, et al, "Perceptions of data literacy and data literacy education," Journal of Librarianship and Information Science, 2024, p. 09610006241246789.

[19] E. Gebre, "Conceptions and perspectives of data literacy in secondary education," British Journal of Educational Technology, vol. 53(5), 2022, pp. 1080-1095.

[20] M. J., Page, J. E., McKenzie, P. M., Bossuyt, I., Boutron, T. C., Hoffmann, C. D Mulrow., ...and D. Moher, "The PRISMA 2020 statement: an updated guideline for reporting systematic reviews". bmj, 372. 2021

[21] I. Y. Song, and Y. Zhu, "Big data and data science: Opportunities and challenges of iSchools," Journal of Data and Information Science, vol. 2(3), 2017, pp.1-18.

[22] A. Grillenberger, and R. Romeike, "Developing a theoretically founded data literacy competency model," In Proceedings of the 13th Workshop in Primary and Secondary Computing Education, 2018, pp. 1-10.

[23] H. R. Khan, J. Kim, H. C., and Chang, "Toward an understanding of data literacy". iConference 2018 Proceedings.

[24] R. Schneider, "Training trainers for research data literacy: a content- and method-oriented approach. In Information Literacy in the Workplace" 5th European Conference, Revised Selected Papers 5, 2018, pp. 139-147.

[25] C. D'Agord, T. Ruggiero, K. Strunk, and M. L. Thurlow. Data analysis and use planning tool for examining AA-AAAS participation: Addressing the percentage of students participating in the alternate assessment. University of Minnesota, National Center on Educational Outcomes, 2019.

[26] T. Irish, A. Berkowitz, and C. Harris, "Data Explorations: Secondary Students' Knowledge, Skills and Attitudes Toward Working with Data," Eurasia Journal of Mathematics, Science and Technology Education, vol. 15(6), 2029, em1686.

[27] L. Pangrazio, and N. Selwyn, "'Personal data literacies': A critical literacies approach to enhancing understandings of personal digital data," New Media & Society, vol. 21(2), 2019,419–437.

[28] K. Schüller. Future Skills: a Framework for Data Literacy-Competence Framework and Research Report, rapport, Berlin, Hochschulforum Digitalisierung, 53, 2020.

[29] A. Gouseti, I. Bruni, L. Ilomäki, M. Lakkala, D. Mundy, J. Raffaghelli, ... and T. Romeu, T. Critical Digital Literacies framework for educators-DETECT project Report 1.: Developing Teachers' Critical Digital Literacies (DETECT) project, Erasmus+, KA2, European Union, 2021.

[30] V. Olari, and R. Romeike, "Addressing ai and data literacy in teacher education: A review of existing educational frameworks," Proceedings of the 16th Workshop in Primary and Secondary Computing Education, 2021, pp. 1-2.

[31] K. Ruedel, L.B. Kuchle, and T. Bailey. Essential Elements of Comprehensive Data Literacy. National Center for Systemic Improvement at WestEd. 2021.

[32] J. Sickler, E. Bardar, and R. Kochevar, "Measuring data skills in undergraduate student work: Development of a scoring rubric," Journal of College Science Teaching, vol. 50(4), 2021, pp. 25-32.

[33] D. Taibi, L. Fernandez-Sanz, V. Pospelova, M. Leon-Urrutia, U. Marjanovic, S. Splendore, and L. Urbsiene, L, "Developing Data Literacy Competences at University: the experience of the DEDALUS project," In 2021 1st Conference on Online Teaching for Mobile Education, IEEE, 2021, pp. 112-113.

[34] S. J. Yates, E. Carmi, E. Lockley, B. Wessels, and A. Pawluczuk. Me and my Big Data: Understanding Citizens Data Literacies Research Report. University of Liverpool. 2021.

[35] C. Gläser, and U. Spree, "Finding access points for data literacy: The example of the ERASMUS+ Project DaLiCo (Data Literacy in Context)" In European Conference on Information Literacy, Springer, 2021, pp. 109-121.

[36] D. Sampson, P., Zacharoula, D. Ifenthaler, M. Giannakos, S. Mougiakou, and D. Vinatsella, "The Learn2Analyse Educational Data Literacy Competence Profile" Educational Data Literacy. Cham: Springer International Publishing, 2022. p. 31-39. https://doi.org/10.1007/978-3-031-11705-3_3

[37] J. Thompson, & G. Arastoopour Irgens. Data detectives: A data science program for middle grade learners. Journal of Statistics and Data Science Education, 30(1), 2022, pp. 29-38

[38] A. C. Vargas, et al. "Towards a framework for Open Data literacy in education: A systematic mapping review of Open Data skills and learning approaches." Interaction Design and Architecture vol. 57, 2023, pp. 133-151.

[39] I. J. Cruickshank, N. D. Bastian, J. R. Blair, C. M. Chewar, and E. Sobiesk, E. "Seeing the Whole Elephant-A Comprehensive Framework for Data Education," In Proceedings of the 55th ACM Technical Symposium on Computer Science Education V. 1, 2024, pp. 248-254.

[40] L. Castañeda, I. Haba-Ortuño, D. Villar-Onrubia, V.I. Marín, G. Tur, J. A. Ruipérez-Valiente, and B. Wasson, "Developing the DALI Data Literacy Framework for critical citizenry," RIED-Revista Iberoamericana de Educación a Distancia, vol. 27(1), 2024 https://doi.org/10.5944/ried.27.1.37773

[41] R. Krüger, and J. Hackenbuchner, "A competence matrix for machine translation-oriented data literacy teaching" Target, vol. 36(2), 2024, pp. 245-275.

[42] E. B. Mandinach. Culturally responsive data literacy. Rowman & Littlefield Publishers, 2024.

[43] C. Qiao, Y. Chen, Q, Guo. et al. "Understanding science data literacy: a conceptual framework and assessment tool for college students majoring in STEM," IJ STEM Ed vol 11-25, 2024. https://doi.org/10.1186/s40594-024-00484-5

[44] C. Matuk, Dikker, S. and Ochoa X. Promoting Students' Data Literacy through the Creation of Interactive Multimodal Representations of Biometric Data. 2024. https://www.nsf.gov/awardsearch/showAward?AWD_ID=2241751&HistoricalAwards=false

[45] K. Miller, S. Yoon, J. Shim, and A. Cottone, "A. Integrating data literacy into secondary school science: An exploratory study of a pilot professional development". In Proceedings of the 15th International Conference of the Learning Sciences, 2021.

[46] J. E Raffaghelli and B. Stewart, "Centering complexity in 'educators' data literacy' to support future practices in faculty development: A systematic review of the literature". Teaching in Higher Education, 25(4), 2020, pp. 435-455. https://doi.org/10.1080/13562517.2019.1696301

[47] J. Atenas, L. Havemann, and C.Timmermann, "Reframing data ethics in research methods education: a pathway to critical data literacy," International Journal of Educational Technology in Higher Education, 20(1), 2023, https://doi.org/10.1186/s41239-023-00380-y