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RESEARCH ARTICLE

Beyond Data Literacy in Engineering Education

How Media Literacy can enhance Data Literacy

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Abstract. Data literacy is a key ingredient for engineering education [1]. Through digital transformation, more data are generated in different scientific fields that will be interpreted. As a highly applicable scientific field, mechanical engineering is predestined to integrate data literacy into the higher education curriculum [2]. However, current frameworks rarely consider ethical questions, agency, and media influences to data [3] . As media and data are closely connected, it is valuable for both literacy framework approaches and researchers to consider each other and enhance their models from one another. Formally, the German Media Science Association has addressed current fallacies in educational policies founded on data literacy frameworks [3]. This contribution aims to incorporate the debate from media educators into the definition of data literacy. Additionally, other emerging literacy frameworks will be considered. In our method, a literature review, current literacies will be discussed in order to introduce the concept of literacy circles. Through this approach, an enhanced data literacy definition will consider frameworks beyond the computer science and engineering field.

1 Introduction

Data literacy is the cross-cutting key for an increasingly data driven society [4]. The term describes a “set of abilities around the use of data as part of everyday thinking and reasoning for solving real-world problems.” [5] Especially for engineering education, its research activities in Industry 4.0, and the development of a national research infrastructure, reflective and critical interaction with data is becoming increasingly important [6] . Moreover, seen in the current societal developments in different democratic countries, there is a risk of incorrect data reading due to incorrect knowledge, which might further foster biases in societal knowledge. Without data literacy, those communicating about data can inadvertently introduce a bias [5] . However, many current data literacy frameworks gloss over the need to develop interdisciplinary reflection to broaden and empower engineers in their decision making. This is due to the fact that they often do not consider other existing research in literacy frameworks such as media literacy. If other scientific fields are included they often address statistical or digital literacy [2]. In focus, aspects

closely related to ethics are often missing in data literacy definitions, as they are sometimes closely used as synonyms for data protection topics [7].

This lack of media in data literacy has been criticized by the society of media science (GfM) in Germany (See part three). The understanding of media literacy has evolved in the last years to go beyond applying a certain set of competencies, towards agency and considerations of media production and reception contexts. Comparing current frameworks in data literacy, they seem to similarly focus on teaching skill sets instead of addressing the complexity with which data driven societies are faced.

The aim of this contribution is to improve data literacy frameworks with the discourse and critique coming from the field of media education science. The research questions is therefore:

- How can data literacy include contexts from other literacy fields (e.g. media literacy)?

The following first part will introduce the current understanding of literacy in general. Then explain core elements in media literacy to explain where understandings from media literacy can be added to data literacy. Additionally, the core critique on existing data literacy frameworks from media literacy perspective will be summarized in the next part. Finally, to further enhance the interdisciplinary exchange towards other literacies, a concept will be introducing data literacy as a coexisting element in a literacy framework. This, concept for a *circle of literacies* has an overlapping core that focuses ethics and is extending to literacies. Finally, the conclusion will summarize key additions to data literacy and open further potential for interdisciplinary exchange and research questions.

2 Literature overview on literacy's

2.1 Literacy terminology

The term literacy is a media related practice [8] [9]. It reflects 'the power and authority to access, interpret, and produce printed texts' [10]. Citing Luke (1989), Livingstone (2004) states that literacy 'masks a complex history of contestation over the power and authority to access, interpret, and produce printed texts' [10] . Because of their everydayness, Media literacy is vital to information and communication technology and can be seen as on of the initial scientific fields that started to develop literacy frameworks in Richard Hoggart's classic work from 1957 "The Uses of Literacy" [8] [10] [11].

Campbell, Lacković, and Olteanu criticize recently the literal (in their words weak) understanding of literacy as 'a determined compendium of skills/competencies' [10]. They stress that literacy itself must be broad enough 'to cover all of a student's meaningful engagements with the world' [8]. They further started to incorporate literacies from other scientific fields, such as media literacy, in order to enhance their sustainability literacy framework. Their approach is inspiring the writing of this contribution in order to further continue the dialogue beyond literacies.

Moreover, literacy is not a state one reaches, but a continuum in which you shift individually depending on the culture and context [12] . This idea was first introduced by Potter in the context of developing an applicable media literacy framework for teachers and students. This understanding of literacy concepts, requires an expansion of the terminological understanding, as literacy becomes more than a collection of competencies for better employability, but rather

a development program to 'a first step towards empowerment [...] of marginalized or misrepresented groups'[10] [13]. This understanding and approach developed in the last decades in media literacy should be further integrated in other literacy frameworks.

2.2 Media literacy contribution to data literacy

In the numerous additional types of literacy, media literacy is one of the earlier literacies with Livingstone to discuss the need to educate children in media interaction [14]. Additionally, media literacy is often being seen as an umbrella term for literacies such as: digital literacy, internet literacy, computer literacy, statistical literacy and even potentially AI literacy [10]. In some other literacy models, like sustainability literacy by Campbell, Lacković and Olteanu, media literacy is incorporated as an integral part of their framework [8]. Among the literacy types, media literacy is a production-oriented practice that is closely connected with the development of agency [9] [10][13].

Agency is understood as 'the capacity to be autonomous and exercise personal power to achieve one's own goals'[13]. It involves factors such as 'individual choice, autonomy, self-determination and creativity' and implies both activity and power [13]. Power in this context refers to the ability to produce effects, to have influence, to make a difference based on informed decisions [13]. Agency is closely connected to ethics as educational programs aim towards fostering the ability to make informed decisions. This informed decision making requires the critical reflection on what has influenced this decision.

Like data literacy, media literacy had focused mainly on developing the skills to access, analyze, evaluate, and create media messages in the past. It has not focused sufficiently on the impact of the actual technological medium, how it enables and constrains both messages and media users [10]. In more recent discussions around media literacy, several researchers such as Shaun Moore (2016), Leaning and Potter call for a non-media-centric media literacy [10] or as Andrew McLuhan describes it *Critical Media Literacy*[15].

The *critical* in critical media literacy is a multi-perspective[10] focus on identity in combination with "explicitly analyzing the 'politics of representation' in media" [15]. With the latest developments and increasing complexity of media, literacy is not only about teaching abilities and skills to create content anymore. The ability to critically analyze and apply values and competencies in the interaction with media are further included in media literacy understandings [10] [16].

In short, classical media literacy stressed the ability to read and write different forms of media, focused on children, and was developed for schools. In contrast, critical media literacy is a shift to a reflective consideration of cultures, contexts, and environments, with the aim to develop agency in citizens, and addressing everyone in the context of life-long learning.

As this discussion is also applicable to other literacy frameworks, the aim of (media) literacy should therefore be to

- make people aware of fact that literacy is a continuum and not a state (realization)
- enable a person to recognize the current literacy level (reflection)
- provide the ability to actively change one's state (agency).

2.3 Data Literacy

There are multiple data literacy definitions, approaches, and frameworks in recent literature. While some researchers see Data literacy as a 'cross-cutting competence' for effective decision making [4] or as abilities to access, use, understand and create digital tools [13], others tend to combine data and digital literacy and describe 'a cluster of behavior and attitudes for the effective execution of value creation process steps on the basis of data' [17]. The German University Forum Digitization base their definition on Ridsdale et al. [18] as 'the ability to collect, manage, evaluate, and apply data with a critical mindset' [17].

Data literacy is the entirety of all efficient behaviors (collect, manage, evaluate and apply) and attitudes for the effective execution of all process steps for value creation and/or decision making based on data [5] [17] [19]. Similar to classical media literacy, most frameworks focus on the ability to read, write, assess, communicate and extract value from data [20].

3 Critique on current data literacy

Media literacy discussions have already gone through the above-described transition towards a broader understanding of media. They have started to address the growing complexity and dynamic in modern societies. Therefore, the German Association of Media Science (GfM), critiques the narrow understanding of data and digital literacy in favor of critical-reflexive methods grounded in media literacy in their position paper [3]. From the discourse, three main critique points are introduced: the critique on terminology, on narrative biases, and on the absence of agency.

3.1 Critique on Terminology

Competencies and literacy are often wrongly used in the literature as synonyms [4] [7] [17]. One core argument from the GfM is the clarification that literacy consist of multiple competencies and thus cannot be understood as synonyms [3]. Schüller et. al mix competencies and literacy constantly in their research, and while the concrete application of literacy frameworks requires the development of competencies, those terminologies are not to be used interchangeably, as they have different meanings [3].

This blurring of terminology is problematic, as different aims and focuses lie behind both words. Competence is the ability to do something, while literacy addresses the ability to understand, evaluate and reproduce something. Competencies do not necessarily include reflection and agency, while this is a needed requirement for being literate. While this definition of competencies already seems to intersect with the literacy definition, Larbig argues that the notion of literacy in the newer understanding implies and encompasses additional aspects in the education process that are not necessarily applied to the understanding of competence [16].

The difference might seem small at first glance. Many early understandings of literacy frameworks were closer to a competence-based understanding. While competencies are often applied in a similar context, the difference lies in the focus of skill development. As the World Economic Forum describes it, competencies are usually a collection of skills, knowledge, attitudes and abilities that enable an individual to perform job roles [21]. This understanding is based on Weinert (2014) [22], who describes knowledge skills and values as the relevant dimensions of

either competences or categories of competencies [2].
Nevertheless, literacy usually combines different competencies that have often evolved around communication, creativity, critical thinking, and collaboration and has expanded further in the media scientific discourse [10]. This reflects the weak and strong literacy understanding from Campbell, Lacković and Olteanu. While the weak literacy considered only its own core topics, a strong literacy also connects to other literacy frameworks and is more directed towards a societal understanding of data. It is less about preparing students for a certain job market, but about enabling people to become empowered citizens through in an increasing data-driven society.

3.2 Critique on narrative bias

The second and main concern of the GfM lies in the lack of cultural, critical, or self-reflective, and creative perspectives in data and digital literacy [3]. As they rightfully point out, data-based solutions shape social interactions, culture, and values profoundly. Therefore, the research in literacy must remain critical [3] instead of collecting and listing techno policy-driven wishes in their frameworks [23]. Literacy research should remain critical towards those developments and should aim for a societal demystification of technological progress.
Additionally, the influence of culture and media in the understanding of real-world-problems seems to barely be considered in current data literacy frameworks [13]. While there are discussions on statistical and visual literacy, the interconnection between other literacies – such as sustainability and media – are not considered, while others such as digital and information literacy are not distinguished [4]. Engineers as well as other professionals working with data need to be trained to become aware of those potential cultural changes through technological design and the associated responsibility they hold as developers of technical solutions.

3.3 Critique on missing agency

Most policy-driven data literacy frameworks explain the need to enable and empower citizens in digital societies to make informed decisions in their everyday lives [2]. The fact that this aim requires the development of agency in literacy frameworks is addressed by the GfM. Rowe states that the media literacy movement has always been about change and agency as the main goal of media literacy [10] [13]. Media Literacy aims ’to empower the youth to be free, capable, autonomous thinkers and doers’ [13].
Similarly, data literacy definitions usually aim to enable citizens to a similar capability [7], but lack active inclusion of agency and might only add critical reflection as a side topic in the form of ethics. However, in the context of data usage in societies, agency is a question of power and empowerment of citizens. Therefore, it needs to be considered to what extend individuals are able to choose and determine who they are, and who they will become [13]. As the collection, visualization and understanding of data shapes our understanding of reality, agency and power dynamics need to be constantly developed and evolved in relation to each other [13].
Developing agency in the context of data literacy is based on cultural and social reflection of actions and their relation to data. As the actions of individuals also produce data – which are in turn the basis for additional decision processes – ethical and critical reflection should not be side topics but are the center of all literacy. Thus, the connection between actions, data and the power to shape of our perceived environment needs a more prominent position in literacy frameworks.

To summarize, the five key takeaways for data literacy from the debate in media literacy:

- Literacy is a continuum, not a state
- Literacy is a collection of competencies, not a competence itself
- To be literate means to critical reflect how technology shapes culture and vice versa
- The aim of literacy is to empower and thus enabling agency should be central in literacy frameworks
- As agency is often thought through critical reflection of power and empowerment it is closely connected to ethics and critical thinking

Those aspects should be further included in current data literacy frameworks and are based in the experience that media educator had developed over the last decade in developing media literacy frameworks.

4 Shift towards literacy circles

Even though, media literacy has a head start in developing literacy frameworks and thus is able to quickly point towards shortcoming in newer emerging literacies, they should not be misunderstood as leading literacy. Apart from the listed critique in the current discussion around data literacy, another underlying element in literacy framework discussions has been the search and fight for being the umbrella term. Definitions often see digital literacy as a meta-literacy, combining information and media literacy [9]. Additional definitions see information literacy as the umbrella term for data and statistical literacy [2], while others see media literacy as an umbrella term for data, visual and digital literacy [10]. On the other hand, media literacy is also described as an integral part of sustainability literacy [8]. This understanding corresponds to the scientific field of the authors and does not reflect the desired interdisciplinary discourse this topic requires. The search for the leading literacy to subsume the others implies a power dynamic that should not exist in a scientific dialogue at eye-level. Moreover, it is not supportive as not all aspects of media literacy are useful additions for data literacy and vice versa.

Therefore, this paper introduces the concept of literacy circles that overlap each other (See Figure 1). Data literacy is positioned between media and digital literacy as data is both consumed and produced in media and digital environments. Visual literacy is closely connected to media literacy and potential other literacies such as statistical literacy. Sustainability literacy overlaps with digital literacy as digital transformation is often seen as solution for a sustainable future. While the positioning of the literacies might need to be investigated further and is not fixed, the core idea is to have literacies all on one level, supporting and overlapping one another.

All literacies merge in the middle of the circle into a field that is called ethical basis. The idea behind the prominent positioning of ethics in the center is that all literacies have the aim to enable citizens to become active and reflective in their decision making (agency). The nature of most ethical questions is that they combine different perspectives and apply additional contexts from other fields. As this agency-related aim often discusses general aspects and extends towards other scientific fields, the focus on ethics is a field where all literacies have a high overlapping degree.

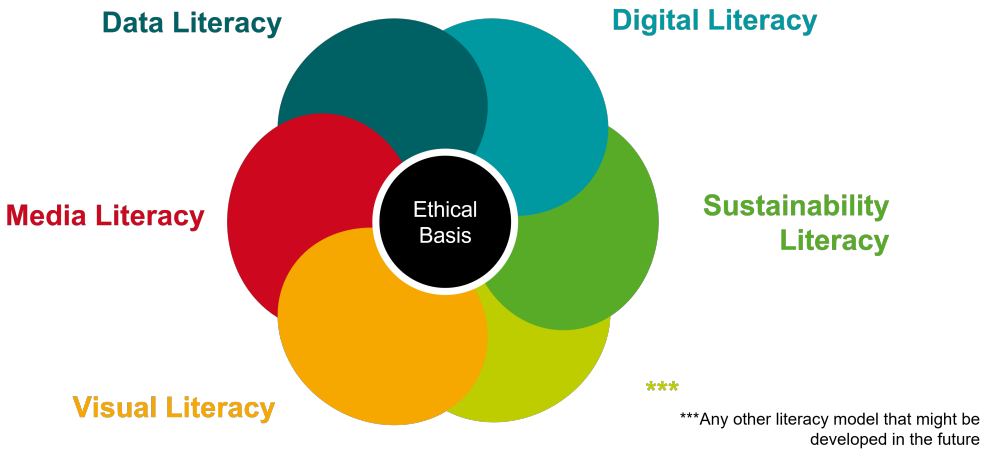

Figure 1: Different literacy circles with overlapping and a common core of ethics

5 Conclusion and Outlook

This paper aims to broaden the understanding of data literacy by including discussions and critiques from media literacy and introducing the concept of the literacy circles. This approach is a step towards developing agency and ethics in the core of a literacy frameworks that move beyond data literacy discussions. To understand the research questions:

- How can data literacy include contexts from other literacy fields (e.g. media literacy)?

First a literature study of various other literacies was conducted. This resulted in three main critiques from media literacy being discussed. The core critique for literacy frameworks are the need to acknowledge literacy and competence as two separate terminologies, recognizing the implicit bias in technological development and the lack of agency based on ethics in current data literacy frameworks. Thus, agency is identified as a common ingredient to empower critical decision-making in literacy. Agency is closely connected to ethics. Thus, a key component in literacy frameworks for empowering citizens to critically think and reflect is ethics. Therefore an ethical basis is the overlapping core with other existing literacy frameworks.

As a result of this discourse, the literacy circles were introduced that indicate how data literacy can be understood in relation to literacies from other scientific fields. At the center of this literacy circle ethics are introduced as foundation that combines all existing and potential future literacies. The shift of ethics into the center is required. The ability to reflect is not limited to one scientific field but is complex through the different perspectives that might appear.

As this concept of literacy circles is not final, further interdisciplinary exchange is needed. For example, the question remains what are the overlapping principles that literacies have in common? This question requires researchers to go beyond their own research domain and exchange their perspectives on research education among other researchers. As shown in this contribution, data literacy can benefit from media literacy when it come to understanding how data representation in media shapes our understanding of the world. However, media literacy has also many aspects from Data Literacy that should be further considered in designing media literacy concepts.

As a further step, the continuation of scientific exchange between different literacy framework researchers is highly recommended and should be strongly encouraged. The question of what topics in ethics combine different literacies should be further investigated to fill the core of the literacy circle with concrete questions to exchange about. Through this interdisciplinary exchange, different scientific fields will all work together to empower professionals, students and educators to make informed decisions in a complex, dynamic and global society.

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7 Roles and contributions

Samira Khodaei: Conceptualization, Execution, Writing, Original Draft

Padev Mihail: Literature Research, Review & Editing

Anas Abdelrazeq: Review & Editing

Ingrid Isenhardt: Review & Editing

References

[1] M. Richter, “Fair data management in engineering sciences in the first semester of the bachelor of mechanical,” in *Data literacy right from the start*, R. Schmidt, Ed., 2022.

[2] K. Schüller, “Ein framework für data literacy,” *AStA Wirtschafts- und Sozialstatistisches Archiv*, vol. 13, no. 3-4, pp. 297–317, 2019, ISSN: 1863-8163. DOI: 10.1007/s11943-019-00261-9.

[3] T. Braun, A. Büsch, V. Dander, *et al.*, “Positionspapier zur weiterentwicklung der kmk-strategie ‹bildung in der digitalen welt›,” *MedienPädagogik: Zeitschrift für Theorie und Praxis der Medienbildung*, pp. 1–7, 2021. DOI: 10.21240/mpaed/00/2021.11.29.X.

[4] D. Taibi, L. Fernandez-Sanz, V. Pospelova, *et al.*, “Developing data literacy competences at university: The experience of the dedalus project,” in *2021 1st Conference on Online Teaching for Mobile Education (OT4ME)*, IEEE, 2021, pp. 112–113, ISBN: 978-1-6654-2814-9. DOI: 10.1109/OT4ME53559.2021.9638912.

[5] A. Wolff, D. Gooch, J. J. Cavero Montaner, U. Rashid, and G. Kortuem, “Creating an understanding of data literacy for a data-driven society,” *The Journal of Community Informatics*, vol. 12, no. 3, 2016, ISSN: 1712-4441. DOI: 10.15353/joci.v12i3.3275.

[6] B. Motyl, G. Baronio, S. Uberti, D. Speranza, and S. Filippi, “How will change the future engineers’ skills in the industry 4.0 framework? a questionnaire survey,” *Procedia Manufacturing*, vol. 11, pp. 1501–1509, 2017, ISSN: 23519789. DOI: 10.1016/j.promfg.2017.07.282.

[7] J. Heidrich, P. Bauer, and D. Krupka, “Future skills: Ansätze zur vermittlung von data literacy in der hochschulbildung,” *Hochschulforum Digitalisierung*, no. 37, 2018.

[8] C. Campbell, N. Lacković, and A. Olteanu, “A “strong” approach to sustainability literacy: Embodied ecology and media,” *Philosophies*, vol. 6, no. 1, pp. 1–20, 2021. DOI: 10.3390/philosophies6010014.

[9] Bryan Alexander, Samantha Adams Becker, Michele Cummins, and Courtney Hall Giesinger, *Digital literacy in higher education, part ii: An nmc horizon project strategic brief*. [Online]. Available: https://www.learntechlib.org/p/182086/.

[10] M. Leaning, *Media and information literacy: An integrated approach for the 21st century* (Chandos information professional series). Cambridge, MA and Kidlington: Chandos Publishing an imprint of Elsevier, 2017, ISBN: 9780081002353. [Online]. Available: https://aml.ca/wp-content/uploads/2017/03/JMLVo.64No.12-2017.pdf.

[11] P. Bennet, J. McDougal, and J. Potter, *Uses of media literacy* (Routledge research in media literacy and education). [S.l.]: ROUTLEDGE, 2022, ISBN: 103240034X.

[12] W. J. Potter, *Media literacy*, Tenth edition. Los Angeles et al.: SAGE, 2021, ISBN: 9781071814451.

[13] M. Rowe, Ed., *The jounral of media literacy*. Madison: National Telemedia Council Inc., 2017, vol. 64.

[14] S. Livingstone, “Media literacy and the challenge of new information and communication technologies,” *The Communication Review*, vol. 7, no. 1, pp. 3–14, 2004, ISSN: 1071-4421. DOI: 10.1080/10714420490280152.

[15] A. McLuhan, *Macro media literacy*, Bloomfield, 2021. [Online]. Available: https://medium.com/@andrewmcluhan/macro-media-literacy-f6352e085c3a.

[16] T. Larbig, *Zwischen kompetenzen und literacy oder: Ohne inhalt keine kompetenz*, herrlarbig.de, Ed., 2009. [Online]. Available: https://herrlarbig.de/2009/09/20/zwischen-kompetenzen-und-literacy-oder-ohne-inhalt-keine-kompetenz/ (visited on 05/25/2022).

[17] K. Schüller and P. Busch, “Data literacy: Ein systematic review,” *Hochschulforum Digitalisierung*, vol. 46, pp. 1–126, 2019. [Online]. Available: https://stifterverband.org/download/file/fid/7908.

[18] C. Ridsdale, J. Rothwell, M. Smit, *et al.*, *Strategies and best practices for data literacy education: Knowledge synthesis report*. 2015. [Online]. Available: https://dalspace.library.dal.ca/bitstream/handle/10222/64578/strategies%20and%20best%20practices%20for%20data%20literacy%20education.pdf.

[19] N. J. van der Wal, A. Bakker, and P. Drijvers, “Which techno-mathematical literacies are essential for future engineers?” *International Journal of Science and Mathematics Education*, vol. 15, no. S1, pp. 87–104, 2017, ISSN: 1571-0068. DOI: 10.1007/s10763-017-9810-x.

[20] M. Leon-Urrutia, D. Taibi, V. Pospelova, S. Splendore, L. Urbsiene, and U. Marjanovic, "Data literacy: An essential skill for the industry," in *Industrial Innovation in Digital Age*, pp. 326–331. DOI: 10.1007/978-3-030-97947-8{\textunderscore}43. [Online]. Available: https://link.springer.com/chapter/10.1007/978-3-030-97947-8_43.

[21] World Economic Forum, "Building a common language for skills at work: A global taxonomy," January 2021.

[22] F. E. Weinert, Ed., *Leistungsmessungen in Schulen* (Ciando library), 3., aktualisierte Auflage. Weinheim and Basel: Beltz, 2014, ISBN: 9783407293183. [Online]. Available: http://ebooks.ciando.com/book/index.cfm/bok_id/1245488.

[23] M. Fanea-Ivanovici and Y.-T. Lee, "An overview of digital literacy frameworks: Focus on the digital literacy framework (cdl)," *SSRN Electronic Journal*, 2022. DOI: 10.2139/ssrn.4088293.