From ethics to engines, framing AI Literacy (including Algorithm Literacy and Data Literacy) through the SEAME framework

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Abstract

Learning about artificial intelligence (AI) and machine learning (ML) could easily become complex and only accessible to a minority; it is imperative that we do not let this happen. The SEAME framework provides a simple way to frame AI literacy including Algorithm Literacy (AlgL) and Data Literacy (DL). The framework's levels are social and ethical aspects (SE), applications (A), models (M), and engines (E). SEAME has been used in research and to develop AI teaching resources. In research, it has been used to frame literature reviews and review teaching resources on AI/ML. In resource development, SEAME has been used to structure teacher professional development, as a basis to produce an AI literacy working definition, and as the backbone of a set of learning objectives and associated lessons to teach about AI/ML to eleven- to fourteen-year-old pupils. This straightforward framework gives students, practitioners, researchers, and policymakers a quick and easy way to start to understand AI. It provides an accessible starting point to develop learning objectives and teaching activities. The framework also helps to review the balance of learning in a subject where it may be too easy to focus on only the more technical aspects and to disassociate ethical issues. In this submission, we present the SEAME framework and examples of its use in practice, including a working definition of AI literacy, references to published academic work and learning materials. The SEAME

framework may be useful in defining and developing the Algorithm and Data elements of AI literacy, and we welcome further discussion about this idea.

1 Introduction

Though AI systems increasingly influence our lives, the issues and underlying technology are not widely understood (Pedro et al. 2019). As part of the journey to common understanding, underpinning definitions must be agreed upon, including what AI Literacy is. Efforts to support learning about AI for school-aged education are increasing (Tedre, Denning & Toivonen 2021, Touretzky et al. 2019). At the same time, research on the impact of classroom AI learning initiatives is limited (Zhou et al. 2020), leaving a vacuum that needs to be filled. In addition, a broad consensus on which AI/ML concepts and skills should be learned is yet to be reached (Tedre, Toivonen, Kahila, Vartiainen, Valtonen, Jormanainen & Pears 2021).

Attempts have been made to define what needs to be taught to be 'AI literate', (e.g. (Long & Magerko 2020, Mandel & Mache 2016, Marques et al. 2020, Torrey 2012, Touretzky et al. 2019, Zhou et al. 2020, Zou et al. 2019)). For learners from five years to eighteen years old, the AI4K12 working group proposed "5 Big Ideas" in AI of: perception, representation and reasoning, learning, natural interaction, and societal impact (Touretzky et al. 2019). Analysing thirty resources aimed at school-aged learners to teach ML Marques et al. (2020) identified twelve ML topics (e.g., neural networks), thirteen ML applications (e.g., sentiment analysis), and seven ML processes (e.g., model evaluation). Other research has considered the tools to support learning about AI/ML, (e.g.,(Hitron et al. 2019, Jatzlau et al. 2019, Lane 2021, Marques et al. 2020)). However, a consensus has yet to be reached in the computing education community. For example, in Germany, Olari & Romeike (2021) raised the issue that most AI Literacy frameworks fail to capture data science (or 'Data Literacy') concepts and skills. Druga et al. (2022) in the USA has called for a 'common language' to characterise and discuss AI/ML teaching resources. Researchers in Brazil, reviewing the literature on teaching ML in high schools, have suggested a need for improved instructional units and supporting technology as well as more rigorous larger-scale research on how to teach ML (Martins & Gresse Von Wangenheim 2022).

UNESCO has suggested in their call for contributions that AI Literacy is a combination of AI-

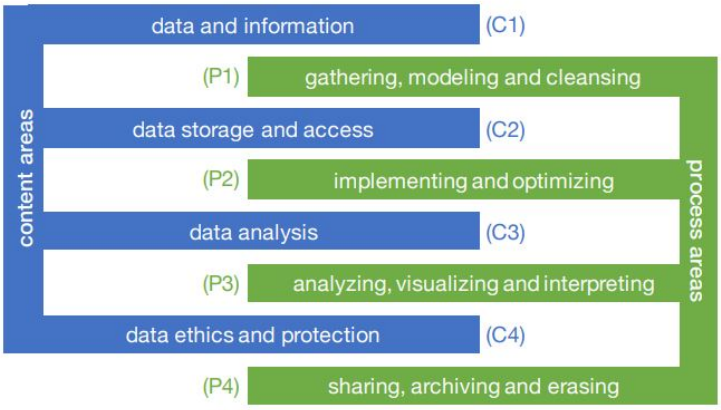

Figure 1: The data literacy competency model (Grillenberger & Romeike 2018, p.6).

gorithm Literacy and Data Literacy. These distinctions are not clearly made within work that has already been done on the teaching and learning of AI and ML, but this approach does resonate with work that has come from some quarters. For example, Grillenberger & Romeike (2018) have suggested a theoretically founded data competency model which provides a comprehensive literature review across learning domains, a set of data literacy definitions, and a synthesis proposing content and process areas for Data Literacy (Figure 2). Similarly, Dogruel (2021) has synthesised the literature on algorithm literacy and suggested dimensions and sub-categories of this concept (Figure 2).

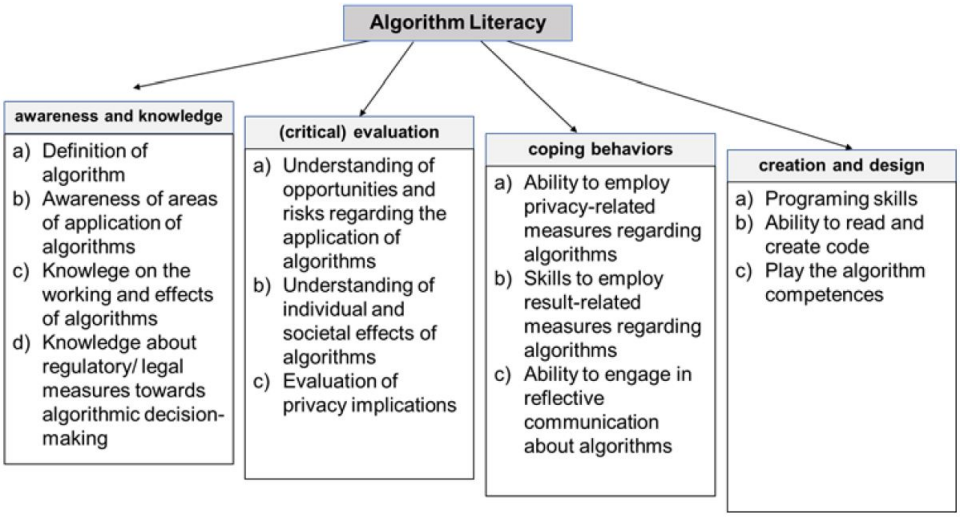

Figure 2: The dimensions and sub-categories of algorithm literacy (Dogruel 2021, p.84).

It is not our intention here to reiterate or review the work of these authors but rather to suggest an overarching framework that can be used, in further work, across these two literacies, to provide a mechanism to compare and contrast and to provide a simple vocabulary to do this.

2 The SEAME framework

We suggest a simple but flexible framework as a starting point, called SEAME (Sentance & Waite 2022), to help support the AI Literacy discussion, including Algorithm Literacy and Data Literacy and related resource development and research. This framework was first used in 2018 to situate teacher professional development on Machine learning (ML) (Waite & Curzon 2018) and has been further refined through research (Rizvi et al. 2023, Waite et al. 2023) and use in resource development (Raspberry Pi Foundation 2023). The SEAME framework provides a simple way to view the teaching and learning of AI and ML, based on whether the focus is on social and ethical aspects (SE), applications (A), models (M), or engines (E). The four levels of the SEAME framework do not indicate a hierarchy or sequence. Instead, the framework affords a common vocabulary for students, teachers, resource developers, researchers and policymakers to talk about the focus of AI Literacy initiatives.

Working with AI industry experts, experienced learning resource developers and AI researchers, and using the SEAME framework as a starting point, we developed a working definition for AI Literacy to situate the creation of teaching materials for the Experience AI learning resources (Raspberry Pi Foundation 2023), of:

> *"AI Literacy is a set of competencies that enables people to use AI applications in everyday life creatively and ethically, to identify and evaluate AI technologies critically, and to have a basic knowledge and understanding of the key concepts and processes associated with AI applications, models, and engines."*

In the following description of each of the SEAME levels, we will exemplify each level through teaching activities from Experience AI.

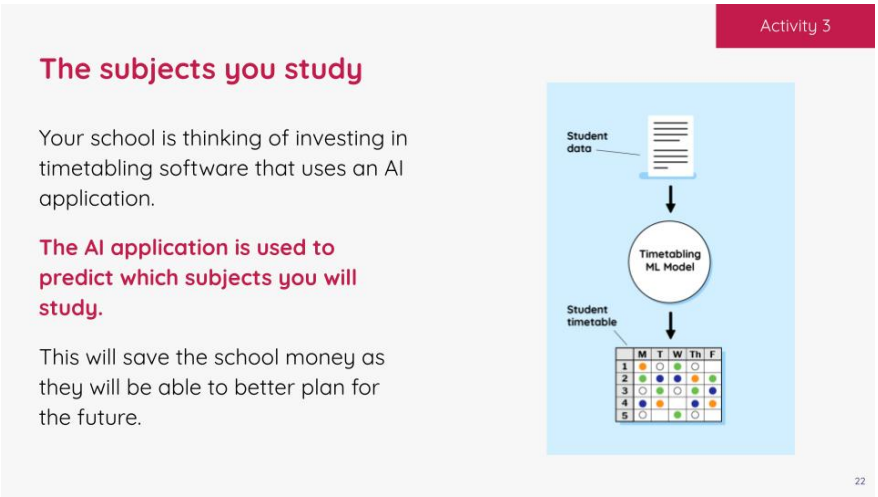

Figure 3: A student AI activity to learn about the social and ethical issues that might influence their daily lives (Raspberry Pi Foundation 2023, Lesson 3).

2.1 Social and ethical (SE)

The SE level focuses on aspects of AI learning that relate to the impact of AI on individuals, groups, and society in general. Learning objectives and their related resources introduce students to issues such as privacy or bias concerns, the impact of AI on employment, misinformation, equity, etc. and the potential benefits of AI applications.

Example learning objectives might include:

- Know some of the benefits to the individual of using AI applications.
- Compare the benefits and issues to society of using AI applications.
- State a range of AI-related careers.
- Name ethical standards and guidelines for the development of ML applications.

As part of the development of a short six-week school-based course for eleven- to fourteen-year-olds in England on AI, SEAME has been used to frame the lesson development (Raspberry Pi Foundation 2023). An example activity from this these materials that include teaching about the SE level is shown in Figure 3. In this activity, students consider different data sets that might be used to train an ML model. This data will be used to predict what subjects students will choose, and from this change the options available to them. Students consider if international data on student choices, national data from all schools from the last forty years, or recent data from their school from the last ten years should be used, and what the social and ethical issues might be.

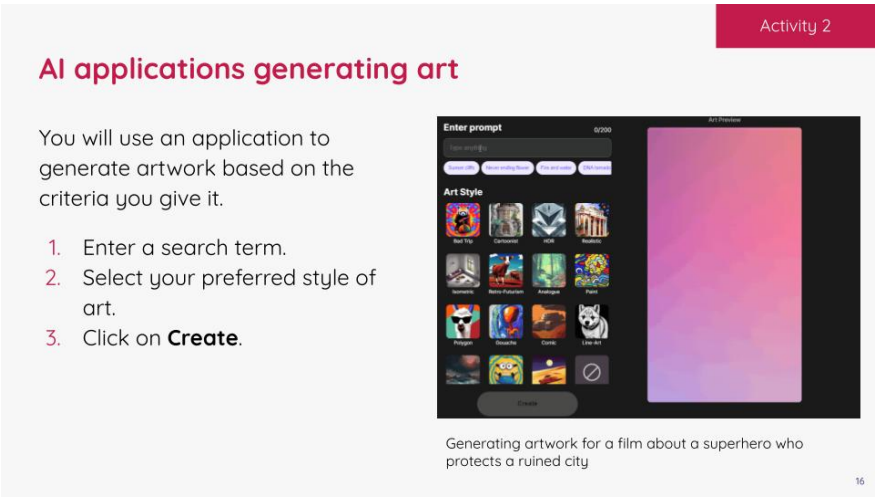

Figure 4: A student activity to learn about AI applications (Raspberry Pi Foundation 2023, Lesson 1).

This level of SEAME is likely to be aligned to elements of Data Literacy such as data ethics and protection (Grillenberger & Romeike 2018) and similarly to Algorithm Literacy such as critical evaluation (Dogruel 2021).

2.2 Application (A)

The A level of SEAME refers to developing applications and systems that use AI or ML models. Learning at this level ranges from recognising AI applications, understanding the difference between rule-based and data-driven approaches (Tedre, Denning & Toivonen 2021), knowing that ML applications use an ML model, and, for learners who have made more progress, how to develop AI applications. This level stops short of training the models that may be called by the application.

Example learning objectives might include:

- Name everyday examples of AI applications.
- Describe the difference between ‘data-driven’ and ‘rule-based’ approaches to application development.
- Identify the parts of a system that are AI and the parts that are not.
- Design and build a simple application that calls an ML model.

An example activity that particularly focuses on the application level includes how students could learn about art-generating AI applications which are starting to become common (Figure 4).

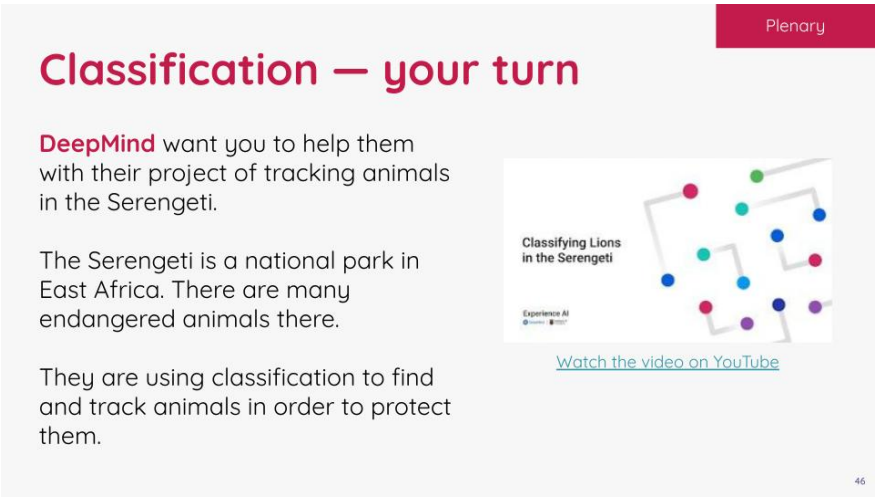

Figure 5: A student activity to learn about the data needed to train classification models (Raspberry Pi Foundation 2023, Lesson 2).

At this level of SEAME, in explaining rule-based and data-driven AI (Tedre, Denning & Toivonen 2021), there will be an interesting consideration of whether Algorithm Literacy (Dogruel 2021) relates to only rule-based models or to both rule and data-driven computational thinking. Research will be needed to investigate this, particularly on potential learner misconceptions.

2.3 Model (M)

Within SEAME, the M level concerns the models underlying AI and ML applications. For ML-based (data-driven models), this includes knowledge and skills to work with data and to train such models. Knowledge related to different machine learning paradigms (e.g. supervised, unsupervised, reinforcement learning) will be considered at this level.

Example learning objectives might include:

- Name common machine learning paradigms (likely to be called approaches).
- Describe how data can impact the accuracy of an ML model.
- Train a simple supervised learning model to solve a simple classification problem.

An example teaching activity that particularly focuses on the M level is shown in Figure 5, in which students learn how data was gathered and classified to train an ML model used by an application to track endangered animals in the Serengeti, East Africa. This level of the framework may be particularly aligned with some elements of Data Literacy competencies such as gathering,

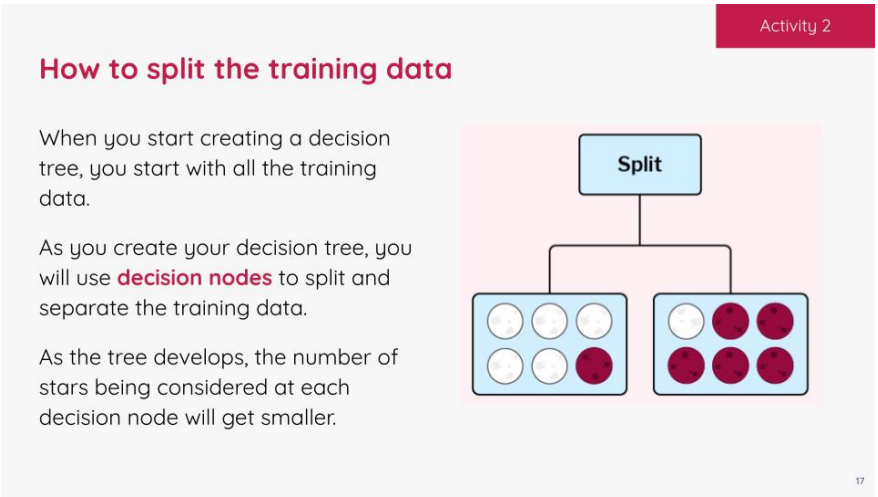

Figure 6: A student activity to learn about decision trees (Raspberry Pi Foundation 2023, Lesson 4).

modeling and cleansing data (Grillenberger & Romeike 2018).

2.4 Engine (E)

The E level is a simplified view of the algorithms and data structures that manage data-driven ML models or rule-based AI and is the most hidden and complex level. Those new to learning about AI may learn about this level using unplugged activities and visualisations. Knowledge and skills will likely include the basic notion of engines such as data-driven decision trees and artificial neural networks. For learners with more experience in AI, the M and E levels are likely to become indistinguishable, but for novices, the distinction is likely to be important to support the simplification of complex concepts. Further research is needed to explore this.

Example learning objectives are:

- Use a decision tree as part of an ML model in a simple unplugged activity.
- Explain in simple terms how neural networks work in an unplugged activity.

An example of an E level learning activity in the Experience AI resources is where students learn about data-driven decision trees (Figure 6). This activity builds on students' knowledge of the data used to train the model level.

This level of the framework may be particularly aligned to elements of Algorithm Literacy, such as knowledge of the working and effects of algorithms (Dogruel 2021) used in engines.

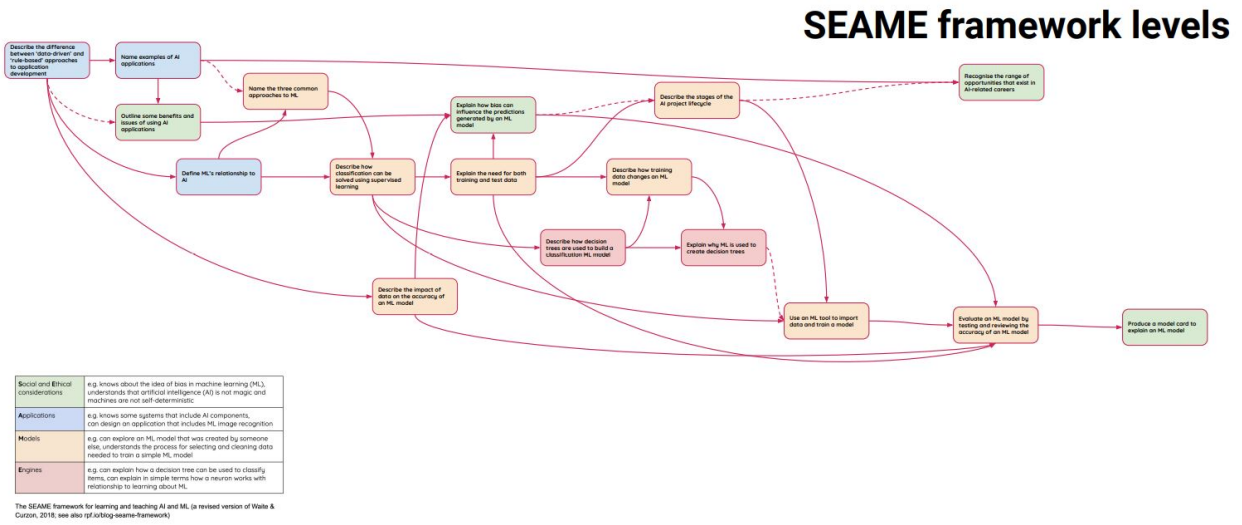

Figure 7: An example of how the SEAME framework can be used to reflect upon a progression of learning objectives (Raspberry Pi Foundation 2023).

2.5 Using the levels

Moving through the levels of SEAME should not be considered a linear process. Lesson activities could focus on a single level but could also be designed to span multiple levels. For example, students could work at the application level using an existing ML model that recognises hand gestures to play a game of rock paper scissors. If this activity was followed by allowing students to use an application such as Google's teachable machine [1] to generate training data to embed within the application, they would be working at the model level. The activity could be followed by an SE level activity in which students explore the accuracy of their model and discuss bias in the training data.

Other activities may be designed to cover several SEAME levels to address a specific concept. For example, an activity focussed on bias might start with an example of the societal impact of bias (SE level). Students could then discuss the AI applications they use and reflect on how bias impacts them personally (A level). The activity could finish with students exploring related data in a simple ML model and thinking about how representative the data is of all potential application users (M level).

We have devised the SEAME framework. It has been used to develop a working definition

[1] `https://teachablemachine.withgoogle.com/`

of AI Literacy (see Section 2) and a set of six lessons on AI. These resources have not been separated by Algorithm Literacy and or Data Literacy competencies (but this could be done). During lesson development, we found SEAME helped us to think about the breadth of learning objectives, completeness and level-specific vocabulary. To support the progression of knowledge and skills across the lessons, we developed a learning graph of learning objectives correlated to the SEAME framework (Figure 7). This graph was used to review the balance of the SEAME levels and to consider transitioning between levels.

For researchers, the SEAME framework may be useful to analyse curriculum material to see whether some age groups have more learning activities at one level than another and investigate whether this changes over time. We may find that younger learners work mostly at the SE and A levels, and older learners move between the levels with increasing clarity as they develop their knowledge. It may also be that some curriculum designers, teachers or students focus on one level rather than others and that the framework serves as a reminder to consider all aspects of AI Literacy in all stages of learning. However, research is needed to investigate the teaching and learning of AI and ML across all ages and stages for Algorithm Literacy and Data Literacy.

3 Conclusion

We propose a simple framework to situate discussion about what is learned about AI Literacy, including both Algorithm Literacy and Data Literacy, called SEAME. We suggest this framework will be useful in developing a view about AI Literacy. The framework has already been used to create a working definition of AI Literacy between industry, academics and resource developers. It has also been used as a backbone for the creation of teaching resources, in research, and professional development, and we are interested in discussing its use on a wider stage.

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