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Algorithm literacy of Polish students of selected faculties in social sciences and humanities

Abstract

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The widespread use and impact of algorithms on almost every aspect of the individual and the society is a significant challenge to the modern world. For effective and informed functioning in today's societies we need algorithm literacy. The development of algorithm literacy must be present in the educational process not only in engineering schools, but also (if not primarily) in the cultural and social studies focused on contemporary cultural changes. Our research focused on the latter. The Algorithm Literacy Scale for Internet Users was used to measure and compare the algorithm literacy of Polish students from three faculties: Architecture of Information Spaces (University of Warsaw), Information in a Digital Environment, speciality: Information Management (University of Łódź), Sociology, speciality: Individual and Contemporary Culture (University of Łódź).

The research had the following goals:

- Preliminary assessment of algorithm literacy among Polish students of selected faculties.
- Testing the Algorithm Literacy Scale for Internet Users in the Polish context and its critical analysis.
- Verifying if students acquired any knowledge on algorithms during their studies.

The study found that:

- There are minor differences in algorithm literacy between faculties, and that some elements of algorithmic awareness and knowledge are widespread, observed in over 90% of respondents, while others – limited, observed in 30% or less of respondents.
- Form of some items on Algorithm Literacy Scale for Internet Users might be unclear and rephrasing should be considered.
- Only six percent of surveyed students indicated university classes as a source of algorithm awareness and knowledge.

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Keywords
algorithm literacy; algorithm awareness; algorithm knowledge; scale critique; Polish students

Introduction

The issue of information literacy and digital literacy has been widely discussed in the fields of information science, social sciences, and media studies for years (Dobson & Willinsky, 2009; Doyle, 1994; Koltay, 2011; Reddy et al., 2020; Snavely & Cooper, 1997). In addition to these terms, the literature includes many other categories, similar in meaning, such as information technology literacy (Ezziane, 2007), media literacy (Livingstone, 2004; Potter, 2013), social media literacy (Festl, 2021; Livingstone, 2014), new media literacy (Chen et al., 2011; Luke, 2007), computer literacy (Hoffman & Blake, 2003), internet literacy (Kim & Yang, 2016; Livingstone, 2008), web literacy (Kuiper et al., 2008), network literacy (McClure, 2018), cyber-literacy (Stiller & LeBlanc, 2006), software literacy (Khoo et al., 2017), data literacy (Koltay, 2017), big data literacy (D'Ignazio & Bhargava, 2015), coding literacy (Hutchison et al., 2016), platform literacy (Žagar et al., 2021), data infrastructure literacy (Gray et al., 2018), and privacy literacy (Bartsch & Dienlin, 2016), algorithm (or algorithmic) literacy.

There are no universally accepted definitions of these terms, making it impossible to definitively determine the relationships between them. Undoubtedly, the semantic ranges of many of these terms overlap to some extent, and perhaps some – in accordance with the principle of Ockham's razor – should be considered redundant. However, the authors believe that the category of algorithm literacy is worth preserving. It is a useful tool to describe a set of competencies necessary for effective and informed functioning in today's reality, dominated by information and communication technologies and increasingly controlled by algorithms.

The concept of an algorithm is associated primarily with computer science, where it refers to a finite sequence of instructions according to which data is processed. This is a common, although colloquial and not strictly scientific, understanding of an algorithm that became established in computer science in the 1960s (Miyazaki, 2012). Defining an algorithm rigorously presents numerous challenges, and some argue that it may be impossible to create a comprehensive formulation (Gurevich, 2012). However, it is usually accepted that algorithms have five key features: finiteness (the algorithm will stop after a finite number of steps), well-defined steps (each step of the algorithm must be clearly defined), input data, out-

put data, and efficiency (each step can be implemented in practice within a finite time) (Knuth, 1973). Algorithms do not have to be deterministic - in other words, their results do not have to be unequivocally determined by the input data. There are probabilistic (or randomized) algorithms that employ a degree of randomness. Most machine learning algorithms used in contemporary artificial intelligence systems are probabilistic.

The role of algorithms in today's world

Digitization drives algorithmization, as digital data can be easily processed by algorithms. Algorithms have become a crucial, if not the primary, mechanism for managing information and knowledge in the social world. They regulate the flow of content on the Internet, match media messages to recipients, and support decision-making processes and the categorization of various elements of the environment around us, including people, in what Lyon (2003) calls "social sorting." Algorithms interfere in individual and social life. They shape our behavior and personal choices (in areas such as entertainment, politics, relationships, finance, health, education, and tourism) and, at the same time, influence the functioning of various organizations, becoming a medium of social reproduction – sometimes strengthening existing structures, and sometimes transforming them.

Initially, algorithms only automated various processes. With the development of systems based on artificial intelligence, especially machine learning, algorithms are becoming more autonomous. So far, it is humans who set the objectives, and algorithms implement them, possibly defining partial goals on their own. However, algorithms are gaining more agency and becoming increasingly complex. Often lacking transparency, they pose the risk of being unexplainable (as is the case with deep learning algorithms, which are frequently difficult or even impossible to interpret), potentially escaping human control. Gillespie (2014) argues that algorithms are perceived as impartial tools, not influenced by subjective assessments, fair, reliable, and error-free, and as such, they have become stabilizers of social trust. However, the impartiality of algorithms is illusory. Each algorithm has specific values and/or interests encoded in it; there is no objective, axiologically neutral algorithm. Algorithmic bias has become the subject of numerous analyses (Arora et al, 2023; Fazelpour & Danks, 2021; Iwasiński, 2020; Johnson, 2021; Kordzadeh & Ghasemaghaei, 2022).

For social sciences and humanities, the key issue is not the technical dimension of algorithms, but their social construction, the meanings and values encoded

in them, and their performative nature (Bucher, 2018; Kreft, 2019; Lindgren, 2023; Szpunar, 2019). From a socio-cultural perspective, an algorithm is therefore more than a set of operations. It is a socio-technological system of knowledge creation, for which culture, norms, and values are no less important than the technical aspects of the code.

What is algorithm literacy?

The concept of algorithm literacy surfaced in the scientific discourse in the middle of the first decade of the 21st century. At that time, this term referred to technical competences related to data analysis needed to conduct advanced scientific research. It was seen as an element of the broader concept of inferential literacy, which included knowledge of general methodology of experimental research, statistics, and data analysis (Miron & Nadon, 2006; Walker & Hughes, 2008). In the following years, the term algorithmic literacy referred mainly to the ability to create computational algorithms. It was closely related to the notions of algorithm skills and algorithm thinking. Both of these terms have been present in the literature since the 1970s. Today, they are used primarily in the context of education and research to describe the ability to design, create, and implement algorithms (the former), as well as a specific type of thinking that is conducive to the effective performance of these activities (the latter). Thus, initially, algorithm literacy only concerned the people creating the algorithms. For about a decade, it has also referred to users of algorithms and individuals or groups who are influenced by them. Algorithm literacy has been proposed as a component of information literacy (Bakke, 2020), data literacy, or digital literacy (Augustinus, 2022; Kampa & Balzer, 2021).

The most comprehensive and complete conceptualization of algorithm literacy was presented by Dogruel in the article *What is algorithm literacy? A conceptualization and challenges eegarding its empirical measurement* (Dogruel, 2011) The concept of algorithm literacy developed by Dogruel comprises two cognitive dimensions (awareness & knowledge, and critical evaluation) and two behavior-related dimensions (coping behaviors, and creation and design).

Algorithm awareness refers to the ability to identify the areas, applications, and devices where algorithms are used. Knowledge concerns users' understanding of how algorithms work. Critical evaluation involves understanding the individual and societal consequences of using algorithms and recognizing the opportunities and risks associated with them. Coping behaviors refer to the application of strat-

egies that allow users to modify settings of algorithms to change their outputs, compare results, and protect privacy. There are three types of coping behaviors: "privacy-related measures (e.g., private browsing, deleting cookies) … result-related measures (e.g., consulting different search engines, deliberately manipulating interactions with algorithms), and third critical communication and activism around algorithms" (Dogruel, 2021). Creation and design refer to users' abilities to modify and create algorithmic applications themselves.

Measuring algorithm literacy

Several studies have aimed at the empirical inquiry of some aspects of algorithm literacy (Brodsky et al., 2020; Bucher, 2017; Eslami et al., 2015; Fouquaert & Mechant 2022; Hobbs, 2020; Klawitter & Hargittai, 2018; Latzer et al., 2016; Powers, 2017; Rader & Gray, 2015; Schwartz & Mahnke, 2020; Taylor & Brisini, 2024). Most of these are qualitative studies of user perception of algorithmic operations on the Internet. Some analyses are focused on awareness of particular algorithm functions, such as awareness of algorithmic curation and awareness of algorithmic personalization on selected Internet servives. Hargittai et al. (2020) proposed examining more general algorithm skills using qualitative interviews. However, this approach makes it difficult to standardize the results.

To our knowledge, only two studies have developed standardized, validated tools for measuring algorithm literacy: AMCA (Algorithmic Media Content Awareness) (Zarouali et al., 2021) and the Algorithm Literacy Scale for Internet Users (Dogruel et al., 2022). Yet, only the latter adopted the notion of algorithm literacy. The former uses the notion of algorithmic awareness.

AMCA (Algorithmic Media Content Awareness) was validated through confirmatory factor analysis. The scale measures algorithm awareness of Internet users. Is is based on a questionnaire consisting of thirteen questions. Authors proposed four dimensions of algorithm awareness:

- content filtering (4 questions);
- automated decision making (3 questions);
- human-algorithm interaction (3 questions);
- ethical considerations (3 questions).

Respondents assess the level of awareness using the Likert scale (1 – *completely unaware*, 5 – *fully aware*). Authors point out, however, that the dimensions of algorithm awareness identified as a result of the analysis of the literature may be incomplete and probably do not cover all relevant areas. Answers are based on de-

clared level of awareness, therefore they cannot be objectified – so the use of such a tool for comparative research is debatable.

Algorithm Literacy Scale for Internet Users is based on Dogruel's conceptualization presented above. However, only one component of cognitive dimension of algorithm literacy has been operationalized – namely awareness of and knowledge. The authors motivate it by two reasons. First, they declare, that "awareness of algorithm use and knowledge about algorithms are considered meta-skills and preconditions for gaining other additional skills." Second, they believe "it is considered insufficient to rely on standardized measures to address behaviors and context-sensitive understanding of algorithms." The authors also showed, that high levels of algorithm awareness and knowledge correlate with reasonable decision-making in practical interactions with algorithms.

The tool consists of a questionnaire containing twenty-two questions:

- awareness of the algorithms used (11 questions);
- knowledge of algorithms (11 questions)

Algorithm Literacy Scale for Internet Users is presented in Appendix B (Table 9 & Table 10).

Research objectives and methodology

The researchers believe that algorithms should be of interest not only to engineering, but also to social sciences and humanities. Algorithms are mechanisms influencing the behavior and choices of individuals and the functioning of various organizations. They are shaped by culture, norms and values. Therefore, algorithm literacy is informed not only by technical, but also by social and cultural knowledge. Algorithms often reinforce the power of hegemonic social structures and reproduce the preexisting biases. In a critical perspective algorithm literacy can be viewed as awareness of this power and the ability to resist it (Cotter, 2020).

The development of algorithm literacy must be present in the educational process not only in engineering schools, but also (if not primarily) in the cultural and social studies focused on contemporary cultural changes. The study is focused on the latter.

The authors regard the research as exploratory. The sample is purposive. The authors chose faculties that were easily accessible to them, and which, in their opinion, should include some form of algorithmic education in their curricula: Architecture of Information Spaces at the University of Warsaw, Information in a Digital Environment, speciality: Information Management at the University of

Łódź and Sociology, speciality: Individual and Contemporary Culture. The authors decided to survey the third (final) year Bachelor's degree students, aiming to examine individuals, who have completed a full cycle of studies

Architecture of Information Spaces is focused on developing skills in the design of information systems and services, analyzing their functionality, examining the needs, and information behaviors of users, as well as designing and analyzing information processes in various types of organizations. Information in the Digital Environment aims to educate specialists in network publishing, and content management, working in information sector institutions. The chosen speciality of Sociology focuses on changes in contemporary culture, of which information and communication technologies are the key element. The curriculum includes courses such as media and mass communication and communication in social media.

All students of the third (final) year of bachelor's degree studies were examined:

- Architecture of Information Spaces (University of Warsaw), $n = 12$;
- Information in a Digital Environment, speciality: Information Management (University of Łódź), $n = 18$;
- Sociology, speciality: Individual and Contemporary Culture (University of Łódź), $n = 17$.

The final sample size was $n = 47$, which included 36 women (76.60%) and 11 men (23.40%). There were no individuals of other genders in the sample. The research was preceded by a pilot study.

The conducted research had the following goals:

1. Preliminary assessment of algorithm literacy among Polish students of selected faculties.
2. Testing the Algorithm Literacy Scale for Internet Users in the Polish context and its critical analysis.
3. Verifying if students acquired any knowledge on algorithms during their studies.

The researchers employed both quantitative and qualitative methods. The Algorithm Literacy Scale for Internet Users was used to measure and compare the algorithm literacy of Polish students from the mentioned faculties. The questionnaire was translated into Polish with minor adjustments for clarity, supported by feedback from the original authors of the questionnaire to ensure that the intention behind the items was properly understood. However, some items were still not fully intelligible to the authors. Therefore, it was decided to investigate whether they were comprehensible to the students. To achieve this, two open-ended questions were added:

1. Were any of the questions unclear? If so, please specify which ones and explain why.
2. Are you unsure about the correct answer to any of the questions? If so, please list them and explain why.

To determine if students acquired knowledge on algorithms during their studies, two additional open-ended questions were used:

1. Was the knowledge acquired during your studies useful in answering the above questions?
2. Are there any subjects in the study program that cover topics related to algorithms (in a technical and/or socio-cultural context)? If yes, what are those subjects and what are the specific topics they cover?

Based on the responses, a coding frame was systematically constructed.
The authors adopted two working hypotheses:

1. Students of different faculties have different levels of algorithm literacy.
2. Not all items in the questionnaire are clear and understandable to our respondents.

To the best of our knowledge, this is the first empirical research on algorithm literacy conducted in Poland.

Findings

Results by fields of studies

All groups scored higher in algorithm knowledge (AK) scale (77.76%) than algorithm awareness scale (61.90%). The overall result for all groups was 69.83%. Students of Architecture of Information Spaces obtained the best results in the entire test (72.73%), students of Information in a Digital Environment got very similar result (71.97%), while students of sociology – the lowest (65.51%). Interestingly, students of Architecture of Information Spaces obtained the best results in AK scale with a score of 81.82%, but not in AA scale – the highest mean in AA scale was achieved in an Information in a Digital Environment group (70.20%) (see Appendix A, Table 6).

Algorithm knowledge analysis

Only 44.68% of the surveyed students knew that "algorithms can develop themselves in a completely different direction from that for which they were created", while only 57.45% correctly identified the following statement as false: „algorithms recognize that results, such as e.g., search results, are incomplete and automatically correct themselves." 8 students marked item 5 (which consisted of those

two statements) as unclear, and 24 considered at least one of the two statements unclear. In the pilot study, most of the surveyed individuals believed that statement 5A ("algorithms recognize that results, such as e.g., search results, are incomplete and automatically correct themselves") refers to a working auto-correct in search engines, while the authors of the questionnaire stated that they meant that algorithms can automatically assess the quality of search results and adjust themselves to acquire better results (see Table 1).

Table 1

Item 5 – score gained by the whole group by each statement

Item	What do you think algorithms do on the Internet?	# of correct answers $n = 47$	%
5A	Algorithms recognize that results, such as e.g., search results, are incomplete and automatically correct themselves	27	57.45
5B	Algorithms can develop themselves in a completely different direction from that for which they were created	21	44.68

Note. False statements are underlined.

Almost all of the students knew that „algorithms are not able to think like human beings" (97.87%). There is widespread knowledge among surveyed students that "algorithms present both chances and risks" (95.74%). Vast majority of them knew that "algorithms are dependent on government censorship" (93.62%), as well as that "when searching for a job online, job offers displayed may vary from person to person despite the same search entry" (91.49%) and that "the use of algorithms which deliver personalized content can mean that the content you find is mostly consistent with your pre-existing opinions" (91.49%). Large majority of students knew that "they can influence algorithms with their internet usage behavior" (89.36%) as well as that "humans are involved when algorithms are used" (87.23%), and that "the database used by an algorithm is decisive in determining its quality" (72.34%). Interestingly, relatively few students knew that "for some media companies, content that is repeated regularly (e.g., traffic reports) is already written by algorithms" (34.04%) (see Appendix A, Table 7).

Algorithm awareness analysis

In item 9 students were asked which devices, from a given list, can be a source of data for algorithms. All except one students (97.87%) were aware that "Internet

browsers are data sources." Other data sources listed in the questionnaire had significantly lower number of indications. Computer games and cell phone towers seem to be the least known (less than half of respondents) sources of data collected for algorithm usage (see Table 2).

Table 2

Item 9 – score gained by the whole group by each statement

Item	There is a large amount of data that can be used in the development and application of algorithms. Here you can see a selection of possible sources	# of correct answers $n = 47$	%
9D	Internet-Browsers (e.g. Internet Explorer, Firefox, Opera, Google Chrome)	46	97.87
9A	Smart speaker (e.g. Alexa)	34	72.34
9B	Smart TV	30	63.83
9C	Wearable computing devices such as activity trackers, heart rate monitors	29	61.70
9E	Electronic payment (credit-, debit cards)	24	51.06
9G	Computer games	20	42.55
9F	Cell Phone Towers	16	34.04

Note. False statements are underlined.

All of the surveyed students (100%) marked correctly that algorithms are used to make product recommendations, and all except one person (97.87%) knew that algorithms personalize advertisements. On the other hand, there was no common awareness of using algorithms to create financial news (stock market) (34.04%) and to create weather podcasts (25.53%) (see Table 3). This supports the thesis that there is common awareness of certain, most discussed forms of algorithms usage, while others are recognized by minority of respondents.

Table 3

Item 10 – score gained by the whole group by each statement

Item	Algorithms are already being used in very different areas. Do you know which of the following functions are often performed by algorithms?	# of correct answers $n = 47$	%
10B	To make product recommendations	47	100.00
10D	To personalize advertisements	46	97.87
10C	To create financial news (stock markets)	16	34.04
10A	To create weather forecast	12	25.53

Note. False statements are underlined.

Understandability of the questionnaire

Open-ended questions regarding the understandability of the items and questions in the questionnaire were added. Respondents were asked if any of the items were unclear (and if so, to explain why) and if they had doubts about the correctness of their answers (and if so, to explain why). The same coding frame was developed for both questions, based on the responses provided by the surveyed students. It was found that 17% of students had difficulty understanding item 5, and 13% had issues with item 9, while items 6 and 10 were formulated clearly (see Table 4).

Table 4

Reasons of lack of understandability of the whole items

		Reason			
Item	**Total**	No reason given	Lack of understanding of the content	Uncertainty about the correctness of the content	Lack of competence
5	**8**	0	3	1	1
6	**0**	0	0	0	0
9	**7**	2	2	0	1
10	**0**	0	0	0	0

Some students declared doubts about the correctness of the answers, especially in item 5 (see Appendix A, Table 8). Mostly they cited lack of competence as the reason of doubts.

Usefulness of knowledge acquired during the studies

Two more open-ended questions concerned knowledge of algorithms acquired during the studies. Coding frame was created. Most of the students (68.09%) did not answer questions regarding the usefulness of the knowledge acquired during their studies for completing the Algorithm Literacy Scale for Internet Users questionnaire. 12.77% of them stated that the knowledge was not useful, the same number of students stated that knowledge was not very useful. Two (4.26%) of the respondents claimed that knowledge was partly useful, and only one, that the knowledge was useful (see Table 5).

Table 5

Usefulness of knowledge gained during studies by the whole group

	Usefulness of knowledge gained during studies	# of references $n = 47$	%
x	No answer	32	68.09
1	*Not useful*	6	12.77
2	*Not very useful*	6	12.77
3	*Partly useful*	2	4.26
4	*Useful*	1	2.13

Note. A coding frame was created to categorize the responses regarding the usefulness of knowledge gained during studies, which was rated on a scale from 1 to 4, where 1 indicates *not useful* and 4 indicates *useful* – none of the responses indicated that the knowledge was very useful.

Critical analysis of the Algorithm Literacy Scale for Internet Users

In the authors' opinion, the intentions behind some of the items in the questionnaire are not clear. The problematic items include:

– "Algorithms recognize that results, such as e.g., search results, are incomplete and automatically correct themselves."

It is not clear what the authors mean by the phrases "recognize" and "correct themselves". This implies that when a phrase is entered into a Google search box and results are returned, the algorithms automatically know if the results are incomplete and make some improvements to themeselves, which is incorrect. While algorithms can learn, this description does not accurately depict the mechanism of machine learning.

– "Algorithms can develop themselves in a completely different direction from that for which they were created."

It is not clear what authors exactly mean by „develop"? Do they mean that algorithms modify their code, or that the results of their activity are different than expected?

– "I can influence algorithms with my Internet usage behavior."

It is not clear what authors exactly mean by "influence"? Does it mean that Internet usage behavior can change algorithm's code, its way of operating or results?

– "Algorithms are able to think like human beings."

Does it mean that algorithms work like human brains (which is absolutely not true) or that algorithms can do things, that intelligent humans do (which is true, however, they do it in a completely different way)?

– "Humans are never involved when algorithms are used."

Involved in what? Does it mean that humans are involved in the process of creating algorithms, and their ideologies, values, biases are inherent to the algorithm? If so, it should be explained in more detail.

The research confirmed that the respondents had trouble understanding the intentions behind some of the items. Moreover, the authors believe that the questionnaire design might be misleading due to having only correct answers in the questions that make up the algorithm awareness scale, resulting in 11 consecutive true answers. The authors suggest that the scale should be balanced, i.e. contain both positive and negative answers.

The Algorithm Literacy Scale for Internet Users measures only one component of the cognitive dimension of algorithm literacy. Therefore the scope of the scale may be too narrow. Algorithm literacy should be considered multi-dimensionally, comprising awareness, and knowledge of algorithms, as well as practical skills of interacting with them; it must include an understanding of at least the basic technical aspects of algorithms, as well as the social and cultural contexts in which they function.

Finally, Algorithm Literacy Scale for Internet Users applies, as the name suggest, to Internet users only. As algorithms are ubiquitous, governing growing number of spheres of individuals' lives and social reality, a comprehensive algorithm literacy measuring tool should not be limited to interactions with Internet algorithms.

Discussion

As this is an exploratory research, the authors may formulate some preliminary conclusions, which cannot be generalized due to the small and non-representative sample. However, these findings may serve as groundwork for future analysis. Higher scores on the Algorithm Literacy Scale for Internet Users were achieved by students in programmes deriving from Information and Library Science (Architecture of Information Spaces and Information in a Digital Environment). Informal conversations with the students confirmed that they are more aware of areas where algorithms are used, have better knowledge of their applications, and understand how they work better than Sociology students.

The research revealed that certain elements of algorithmic awareness and knowledge are widespread (observed in all or almost all students), while other elements are limited, observed in only a minority of respondents. The authors found that 98% of surveyed students understand that algorithms cannot think like humans. Over 90% knew that algorithms may be influenced by state censorship,

that job offers displayed online may vary from person to person despite the same search entry, and that the use of algorithms to deliver personalized content can result in finding information mostly consistent with pre-existing opinions. This indicates that most students are aware of the filter bubble mechanism. Additionally, 100% of students are aware that algorithms are used to recommend products on the Internet, and 98% know they are used to create personalized advertisements. Furthermore, 98% of the surveyed individuals are aware that web browsers are a source of data for algorithms, while only 34% are aware that cell phone towers are also a source. One-third of respondents knew that some media companies use algorithms to write regularly repeated content (e.g., traffic reports), the same percentage is aware that algorithms are used to create financial news, and only one-fourth know they are used to create weather forecasts.

Results confirmed that respondents had trouble understanding the intentions behind some of the items. Comprehension or interpretation issues may be, to some extent, due to translation. The authors of the questionnaire declare: "our original scale was developed in German … Items worked in the context of our study, but item length or use of words to increase or decrease item difficulty might be critical in other languages." It is worth considering rephrasing some of the items. Additionally, referencing real-life examples of algorithm operations to illustrate the problems stated in particular items might make them clearer and more palable.

Surprisingly, just slightly over six percent of surveyed students indicated university classes as a source of algorithm awareness and knowledge (two percent said they were definitely useful, and four percent said they were partially useful). Only students of Architecture of Information Spaces were able to name any courses that covered these issues. Most of students declared that they acquired algorithm literacy on their own, mainly through practical interaction with algorithm-based technologies. This discovery should give food for thought to decision-makers responsible for preparing university programs in Poland. Developing algorithm literacy should be an obligatory part of media education and digital education - not just in computer science studies, but in all fields of study interested in contemporary culture, which is increasingly shaped by algorithms.

Conclusions

– The study found that there are minor differences in algorithm literacy between courses – with Architecture of Information Spaces having the best results (72.73%), and Sociology – the lowest (65.51%).

- All groups scored higher in algorithm knowledge scale (77.76%) than algorithm awareness scale (61.90%).
- Some elements of algorithmic awareness and knowledge are widespread, observed in over 90% of respondents, while others – limited, observed in 30% or less of respondents.
- Form of some items in Algorithm Literacy Scale for Internet Users might be unclear and rephrasing should be considered. Illustrating items with real-life examples could make them more comprehensible.
- Construction of the Algorithm Literacy Scale for Internet Users questionnaire might be confusing.
- There is a need of creating a comprehensive algorithmic literacy measuring tool not limited to interactions with Internet algorithms
- Respondents generally declared that the knowledge gained during their studies was not useful to answer the questions in the questionnaire.

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Appendix A

Table 6

Results of Algorithm Knowledge (AK) and Algorithm Awareness (AA) scales by fields of study

		Total		AIS				IDE				S			
Scale	Item	M (%)	SD (%)	M (%)	SD (%)	M (%)	SD (%)	M (%)	SD (%)	M (%)	DS (%)	M (%)	SD (%)	M (%)	DS (%)
AK	5	77.76	12.26	51.06	47.19	81.82	14.50	58.33	51.49	73.74	10.75	27.78	39.19	79.14	11.48
	6			83.69	11.55			87.04	11.44			83.95	13.32		
AA	9	61.90	20.12	60.49	24.05	63.64	19.38	65.48	23.95	70.20	18.40	69.05	23.63	51.87	18.95
	10			64.36	20.68			60.42	16.71			72.22	22.51		
	Total			**69.83**	**11.23**			**72.73**	**13.84**			**71.97**	**7.99**		

Note. This table demonstrates the results of third year students of the following faculties: AIS – Architecture of Information Spaces at the University of Warsaw; IDE – Information in a Digital Environment, speciality: Information Management at the University of Łódź; S – Sociology, speciality: Individual and Contemporary Culture at University of Łódź.

Table 7

Item 6 – score gained by the whole group by each statement

	You will now see some statements about algorithms, some of them are true, some are false	# of correct answers $n = 47$	%
6E	Algorithms are able to think like human beings	46	97.87
6G	Algorithms present both chances and risks	45	95.74
6F	Algorithms are independent of government censorship	44	93.62
6C	When searching for a job online, job offers displayed may vary from person to person despite the same search entry	43	91.49
6D	The use of algorithms which deliver personalized content can mean that the content you find is mostly consistent with your pre-existing opinions	43	91.49
6A	I can influence algorithms with my internet usage behavior	42	89.36
6I	Humans are never involved when algorithms are used	41	87.23
6B	The database used by an algorithm is not decisive in determining its quality	34	72.34
6H	For some media companies, content that is repeated regularly (e.g., traffic reports) is already written by algorithms	16	34.04

Note. False statements are underlined.

Table 8

Reasons for doubts about the correctness of the answers.

		Reason			
Item	**Total**	No reason given	Lack of understanding of the content	Uncertainty about the correctness of the content	Lack of competence
5A	**17**	6	2	3	6
5B	**14**	5	1	2	6
6A	**7**	1	0	1	4
6B	**6**	1	0	0	4
6C	**6**	1	0	0	4
6D	**6**	1	0	0	4
6E	**8**	1	0	0	5
6F	**9**	2	0	1	5
6G	**8**	1	1	1	4
6H	**6**	1	0	0	4
6I	**7**	1	0	0	4
9A	**7**	1	0	1	5
9B	**7**	1	0	1	5

9C	**6**	1	0	1	4
9D	**6**	1	0	1	4
9E	**6**	1	0	1	4
9F	**6**	1	0	1	4
9G	**7**	1	0	1	5
10A	**10**	1	0	4	5
10B	**10**	1	0	4	5
10C	**13**	1	0	5	7
10D	**10**	1	0	4	5

Appendix B

Algorithm Literacy Scale for Internet Users

Table 9

Algorithm Knowledge Scale – Item Overview

Lead	Answer options	Item ID	Item
What do you think algorithms do on the Internet?	True / False	5A	Algorithms recognize that results, such as e.g., search results, are incomplete and automatically correct themselves
		5B	Algorithms can develop themselves in a completely different direction from that for which they were created
You will now see some statements about algorithms, some of them are true, some are false	True / False	6A	I can influence algorithms with my internet usage behavior
		6B	The database used by an algorithm is not decisive in determining its quality
		6C	When searching for a job online, job offers displayed may vary from person to person despite the same search entry
		6D	The use of algorithms which deliver personalized content can mean that the content you find is mostly consistent with your pre-existing opinions
		6E	Algorithms are able to think like human beings
		6F	Algorithms are independent of government censorship
		6G	Algorithms present both chances and risks
		6H	For some media companies, content that is repeated regularly (e.g., traffic reports) is already written by algorithms
		6I	Humans are never involved when algorithms are used

Note. False statements are underlined.

Table 10

Algorithm Awareness Scale – Item Overview

Lead	Answer options	Item ID	Item
There is a large amount of data that can be used in the development and application of algorithms. Here you can see a selection of possible sources	Is used / Is not used	9A	Smart speaker (e.g. Alexa)
		9B	Smart TV
		9C	Wearable computing devices such as activity trackers, heart rate monitors
		9D	Internet-Browsers (e.g. Internet Explorer, Firefox, Opera, Google Chrome)
		9E	Electronic payment (credit-, debit cards)
		9F	Cell Phone Towers
		9G	Computer Games
Algorithms are already being used in very different areas. Do you know which of the following functions are often performed by algorithms?	Are performed / Are not performed	10A	To create weather forecasts
		10B	To make product recommendations
		10C	To create financial news (stock markets)
		10D	To personalize advertisements

Note. False statements are underlined.