A Systematic Review of 'Algorithmic literacy' in Literacy Education

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I. Introduction

Literacy is a constructive concept that varies according to the media environment and social changes. From this point of view, it is a natural phenomenon that 'new literacies' are constantly presented. The emergence of a new literacy is the result of diversifying the types of literacy, but also of subdivising the existing literacy. In particular, this subdivision of literacy is closely related to changes in the media environment. For example, as news platforms diversified, discussions differentiated from traditional news literacy were created, such as news literacy in the Facebook news feed environment.

It is worth noting that the difference between these subdivided literacies is by no means small. For example, the news literacy required in the Facebook News Feed environment is distinctly different from that required in the traditional mass media environment. Because Facebook News Feed selects and excludes news based on arbitrary criteria that recommends personalized news to users, it calls for a new literacy practice that can critically engage in news curation. In this way, the subdivision of literacy leads to the emergence of new literacy.

From this point of view, this study aims to pay attention to 'algorithmic literacy' as a 'new literacies' based on the fact that 'algorithm' is the key element that characterizes the current media environment.

Algorithms combined with AI as a "non-human actor" have a huge influence on human life and culture such as making decisions like humans or before humans (Pyun, 2022). As a result, in various academic fields, the need to develop human abilities to know about and engage in algorithms has been raised. The discussion of algorithmic literacy, which refers to the ability to know and critically engage to algorithms, was born in this context.

It is a well-known fact that literacy education is responsible for knowing what literacy is required by society and preparing specific educational discourses for it. Therefore, literacy education needs to pay attention to algorithmic literacy as a new literacy required by the current society. But, in order for valid and effective literacy education research to be conducted, it is necessary to thoroughly organize, analyze, and evaluate the study achievements and trends so far. Therefore, this study attempts to explore how algorithmic literacy research has been and should be progressed in literacy education through a systematic review.

Of course, since algorithmic literacy is the newest research topic, it is highly likely that research achievements have not been sufficiently accumulated. Nevertheless, the reason for using 'Systematic Review' is to scientifically investigate related literature. Through the process of systematically organizing and analyzing studies, it is expected that implications for how algorithmic literacy education should be constructed will be obtained.

The first step in systematic review is to set the 'Key Question'. The key question is a description of the research purpose in the form of a question, which is the criterion for determining what literature to include (Kim et al., 2011). The key questions to explore the trend of algorithmic literacy in various aspects were set as follows.

First, in the field of literacy education, how about the publication trend of algorithmic literacy research is?, and what is the definition of algorithmic literacy?

Second, what are the topics and keywords of algorithmic literacy

research in literacy education?

Third, what are the subjects and methods of algorithmic literacy research in literacy education?

Fourth, what are the content of and the teaching methods of algorithmic literacy education?

II. Methods

Systematic Review (SR) is a scientific literature review method that collects, confirms, assesses, and synthesizes all related studies to derive answers to key questions. Specific research procedures are 'setting key questions, defining the scope of literature, searching the literature, selecting and assessing the studies, synthesizing and analyzing the studies, and presenting the results' (Kim et al., 2011).

First, the scope of the literature was defined to obtain answers to key questions. In this process, it is important to define the scope of the literature so that all studies related to key questions can be collected, so the publication period, publication format, and combination of search terms should be comprehensively considered (Kim et al., 2011). In this study, it is important to collect as many studies on algorithmic literacy as possible, so search terms were diversified into synonyms and related words, and there were no restrictions on the publication period and format. In general, SR strictly limits the publication format to consider the validity and reliability of the literature. However, the research on algorithmic literacy is in its early stages, and the purpose of this paper is to outline how related studies are conducted in literacy education rather than evaluating academic achievement of algorithmic literacy studies, so it included research reports, dissertations, and proceedings. Of course, only literature with clear sources was included.

Next, representative journal search sites were used to collect reasonable data and comprehensive search. In addition to RISS, DBpia,

and KISS, which can search for Korean literature, the search was conducted using ERIC and Google Scholar which are useful for searching foreign literature. All academic journals, research reports, dissertations and proceedings related to algorithmic literacy searched on these five search sites were selected as initial search targets.

The literature search was conducted from July 31 to August 10, 2022. In order to review both domestic and foreign literature, the search term was entered by combining 'algorithmic literacy/알고리즘 리터러시', 'algorithm/알고리즘', 'literacy/리터러시/문해력', and 'literacy education/instruction/교육/지도/수업'. In order to collect as much literature as possible, a search was conducted for titles, abstracts, and body text. In this process, business administration, law, advertising, and computer studies that were not related to literacy education were excluded. A total of 92 initial search results were obtained, excluding duplicate documents on each search site.
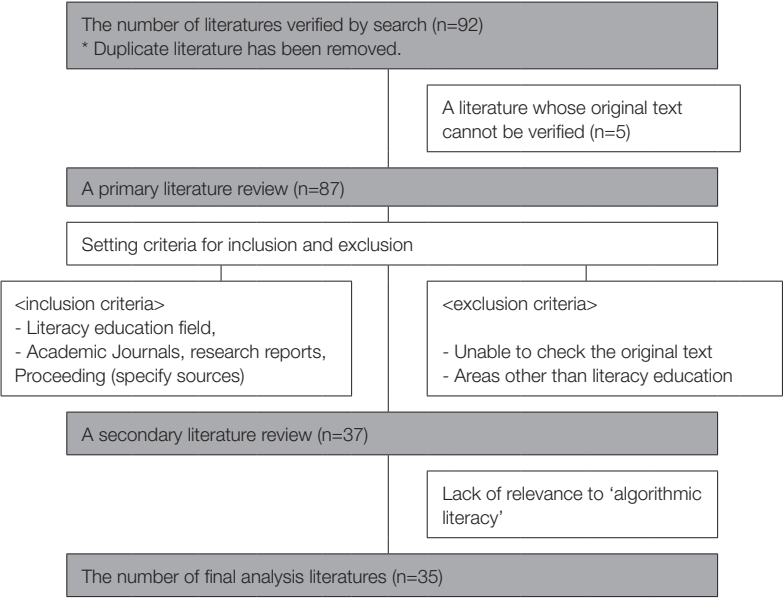

Figure 1. Procedures and results of studies selection

After removing five studies that original text could not be confirmed, the first literature review was conducted. In this process, literature was screened and classified using selection and exclusion criteria. Specifically, based on the title, abstract, and conclusion, the literature was selected by examining whether the main purpose of the study was to construct literacy educational discourses. In this process, studies in science, music, and programming education was excluded. However, studies in library education were included because those were a discussion aimed at improving ability of reading and writing in an algorithmic environment.

The second literature review was conducted on the 37 papers selected in this way. In the second literature review, cases where 'algorithmic literacy' was mentioned, but was not the main focus of the study, were excluded. After these processes, 35 studies remained to be reviewed.

The studies selected through the above process were analyzed based on the analysis framework in Table 1. Since the analysis framework should consist of items that can answer the four key questions, a total of six analysis categories were set: year of publication, subject, research method, research topic, keyword, and education plan (content and teaching method).[1]

Table 1. Analysis Framework

Categories	Explanation
The year of publication	• Categorized by year

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1   Among the six categories, general classification criteria were applied for the year of publication, subject, and research method. However, research topics, keywords, and educational plans had to be analyzed inductively based on content analysis. Therefore, after deriving the core contents of each study, subcategories were created by considering the similarity and hierarchy of the content.

T o p i c	① The pursuit of changes in literacy education according to the algorithmic environment		• A study that raised the need for overall change in education, such as the perspective, content, and teaching method of literacy education in consideration of the algorithmic environment.
	② Suggestion of algorithmic literacy education plan	②-1. theory-based	• A study that presents the educational principles, contents, and methods of algorithmic literacy based on the results of literature review, research, etc.
		②-2. Case-based	• A study that presented the educational principles, contents, and methods of algorithmic literacy by analyzing the cases of actual classes
	③ Investigate perceptions of literacy in an algorithmic environment		• A study on the user's perception (understanding and level) of the presence of algorithms and the change of literacy according to algorithms
	④ Investigate literacy practices in algorithmic environments		• A study on the user's literacy performance (strategies, success and failure cases, etc.), learning path, and learning process in an algorithmic environment
	⑤ Exploring changes in algorithmic environment, concepts of literacy, and characteristics		• A study on the concept of literacy (meaning and elements) and the characteristics of the media (text) environment changed by the appearance of algorithms
Keywords			• A list of <keywords> in the literature If there is no list of <keywords>, key concepts and terms repeated in the literature
M e t h o d	Literature review		• A study based on relevant literature
	Quantitative method		• A study conducted by collecting quantified data and applying statistical models
	Qualitative method		• A study on the in-depth meaning analysis by collecting discourse and observation data
	Mixed method		• A study using both quantitative and qualitative studies

Subject	Adolescent	• Elementary, Middle, and High school students
	Undergraduate	• University student
	Instructor	• Literacy educators and prospective teachers in educational institutions
	General Adult	• All adults not included in the preceding classification
	Mixed	• When the subjects listed above are mixed
Contents	Critical understanding of how algorithmic systems work and their consequences, and their rhetorical practices	• Contents of education related to critical understanding of the technological context of algorithm operation, such as algorithmic personalization and attention economic logic, and phenomena caused by the rhetorical practice of algorithms (e.g., search distortion and bias)
	Critical reflection on the sociocultural context behind the algorithm	• Contents on the relationship between algorithms and power, especially critical reflection on data collection, surveillance, and control by economic or political actors
	Critical understanding of ethical issues caused by algorithms	• Contents on recognition and critical understanding of ethical issues such as reproduction of prejudice and inequality due to algorithm search, privacy infringement, etc.
	Algorithmic literacy knowledge and strategy	• Contents on basic knowledge (e.g., algorithmic differences by platform), technology (distinguished from programming ability), and strategy related to detailed functions of algorithmic literacy

III. Findings

1. Publication trends and definitions of algorithmic literacy

In literacy education, studies related to algorithmic literacy were

published around 2020. The earliest study of the 35 literature is Beveridge's "Writing through Big Data: New Challenges and Possibilities for Data-Driven Arguments", published in 2017. Although the term 'algorithmic literacy' is not directly used, this study presents the need and plan for data-based argumentation education, focusing on the ability to solve to ethical and political problems caused by algorithm filtering on Big data.

Based on the literature collection period, the year in which the most studies were published is 2020. Pariser proposed the term 'filter bubble' in 2011 to warn of the dangers of information bias caused by algorithms and the sociocultural, political, and economic issues it causes. Also, with the US presidential election held in 2016, it was raised that fake news using social media platforms and algorithms threatens democracy, and the algorithmic issue has become full-fledged. Considering these facts, it can be seen that the discussion of algorithmic literacy started relatively late in literacy education.
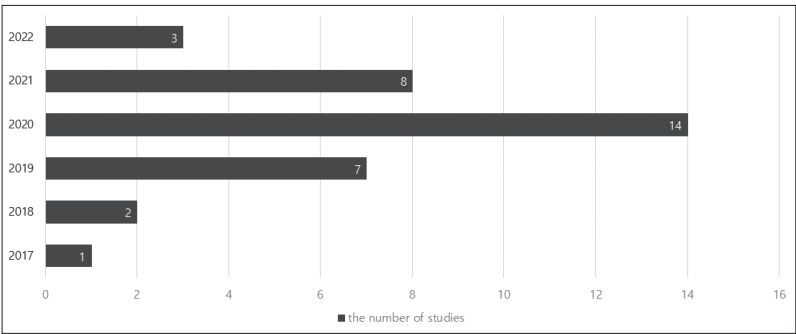

Figure 2. Number of studies by year

In this regard, it is meaningful to investigate how algorithmic literacy is defined in literacy education research. Because how the concept is defined reflects the perspective of the field on the issue, the direction of interest, and the accumulated research achievements. As a result of the analysis, 10 studies defined 'algorithmic literacy' (Table

2), and 7 studies simply mentioned or used the term (Aleman et al., 2021; Bakke, 2020; Dezuanni, 2021; Henderson et al., 2020; Hur & Jeong, 2020; Jeong et al., 2022; Ptaszek, 2020).

In studies that did not directly mention the term algorithm literacy, related concepts were mentioned (algorithm awareness: Brodsky et al., 2020; post-human literacy: Leander & Burriss, 2020) or literacy concepts required in an algorithmic environment such as critical literacy (Hong, 2022; Leander & Burriss, 2020; Lee & Kwon, 2020; Pyun, 2022), media literacy (Cohen, 2018; Hobbs, 2020; Hur & Jeong, 2020; Jeong & Hur, 2020; Valtonen et al., 2019), digital literacy (Bhatt & MacKenzie, 2019; Brandon, 2021; Marlatt & Sulzer, 2021; Souza, 2018), information literacy (Gardner, 2019), data literacy (Beveridge, 2017), and critical thinking (Ku et al., 2019) were used instead.

In particular, these studies emphasized the importance of literacy, referring to the characteristics of the media environment in which algorithms intervene as a agent of producing, consuming, and circulating information, and the problematic phenomenon caused by it (e.g., fake news, representation of bias, dataveillance by private companies, value-biased algorithm filtering, etc). This proves that these studies understand the concept of algorithmic literacy, although they do not use the terms.

Table 2 is a summary of the definitions of the 10 literature that specifically defined the algorithmic literacy.

Table 2. Definitions of algorithmic literacy

Study	Concepts and Definitions
Glotfelter (2019)	• algorithmic literacy: that would help users be • more critical of the experiences they have on social media platforms (p. 12)
Lloyd (2019)	• algorithmic literacy: As part of information literacy, "reflexivity which can focus our attention on how algorithms are expressed and operationalised(through our actions and interactions with interfaces and programs), along with the conditions,

	assumptions and biases that are inherent in their production and operationalisation." (p. 1483)
Cotter (2020)	• critical algorithmic literacy: recognizes knowledge as situated, constructed within and in relation to the discursive landscape of social worlds, and involving the cultivation of a critical consciousness through recognizing and responding to algorithms as expressions of broader systems of power. (p. 3)
Dasgupta & Hill (2020)	• critical algorithmic literacy: intellectual tools that allow young people to understand and critique the algorithmic systems that affect their lives (p. 1)
Head et al. (2020)	• algorithmic literacy: a subset of information literacy, algorithmic literacy is a critical awareness of what algorithms are, how they interact with human behavioral data in information systems, and an understanding of the social and ethical issues related to their use (p. 49)
Koenig (2020)	• algorithmic literacy practices: ①basic understanding of how algorithms function (mathematically), ②how they are used to reinforce traditional power structures(socially, politically, and economically) and ③how humans can recognize and act upon their own agency when interacting with algorithmic (p. 3)
Swart (2020, 2021)	• algorithmic literacy: the combination of users' awareness, knowledge, imaginaries, and tactics around algorithms (2021, p. 2)
Pegrum & Palalas (2021)	• algorithmic literacy: As a sub-factor of information literacy and critical literacy, "ability to understand the operation and impact of data-driven algorithms" (p. 4)
Ridley & Pawlick-Potts (2021)	• algorithmic literacy: It is the skill, expertise, and awareness to: ①Understand and reason about algorithms and their processes, ②Recognize and interpret their use in systems (whether embedded or overt), ③Create and apply algorithmic techniques and tools to problems in a variety of domains, ④Assess the influence and effect of algorithms in social, cultural, economic, and political contexts, ⑤Position the individual as a co-constituent in algorithmic decision-making (p. 4)

Although there are some differences in the refinement of concepts, literacy education generally defined algorithmic literacy as the ability to critically reflect on the 'context' and 'influence' of the algorithm operation, as well as technological understanding of the algorithm itself and its operating system.

The 'context' at this time includes the technical structure of algorithmic operation as well as the macroscopic context of political, economic, and social influences that intervene in the production, consumption, and circulation of information in an algorithmic environment. In addition, 'influence' refers to literacy issues (e.g., filter bubbles, datafication, fake news, algorithmic identity) and social-ethical issues (e.g., representation of discrimination and prejudice, distortion of information) caused by algorithms.

This definition suggests that algorithmic literacy in literacy education is viewed as a communication ability to accurately and critically understand and engage in various sociocultural, political, and economic issues and phenomena related to algorithms rather than computer programming technology. In addition, it can be confirmed that algorithmic literacy is emphasized as essential literacy in human life by claiming that the scene requiring algorithmic literacy is not limited to computer expertise, but to the overall human activities such as society, economy, politics, and ethics.

2. Research topics and keywords

In literacy education, the proportion of studies suggesting the content or teaching method of algorithmic literacy was the highest (②: 12 studies). In addition, studies that examined the algorithm environment and the resulting changes in the concept and characteristics of literacy (⑤: 8 studies) and emphasized the need for changes in literacy education in consideration of the algorithm environment (①: 8 studies) also accounted for a large portion.

The large proportion of ① and ⑤, which build he foundation of

educational discourse, is related to the fact that algorithmic literacy research is in its early stages in literacy education.

Table 3. Categorization by topic

Topic	n	Studies	
①	8	Bhatt & MacKenzie (2019), Dezuanni (2021), Hobbs (2020), Lee (2021), Lee & Kwon (2020), Pawlick-Potts (2021), Ptaszek (2020), Ridley & Souza (2018)	
②	12	❶	Bakke (2020), Dasgupta & Hill (2020), Head et al. (2020), Jeong & Hur (2020), Valtonen et al. (2019)
		❷	Aleman et al. (2021), Beveridge (2017), Brandon (2021), Gardner (2019), Henderson et al. (2020), Hur & Jeong (2020), Jeong et al. (2022)
③	3	Brodsky et al. (2020), Koenig (2020), Marlatt & Sulzer (2021)	
④	4	Glotfelter (2019), Ku et al. (2019), Swart (2020, 2021)	
⑤	8	Cohen (2018), Cotter (2020), Hong (2022), Leander & Burriss (2020), Lloyd (2019), Moon (2019), Pegrum & Palalas (2021), Pyun (2022)	

In this situation, it is particularly noteworthy that the proportion of ② suggesting specific educational plans is the largest. As a result of the analysis, these studies aimed to revitalize algorithm literacy education by suggesting specific educational plans (Beveridge, 2017; Gardner, 2019; Aleman et al., 2021), pointing out that education is not 'quickly' reflecting the reality that the influence of algorithms has grown to the extent that the term 'algorithm culture (Henderson et al., 2020)' has been coined. Accordingly, a study was conducted to find a direction for improvement based on the results of analyzing actual education cases (②-❷) or to specifically design 'authentic' education principles or 'effective' teaching methods based on theoretical grounds (②-❶).

In order to understand the distribution characteristics of topics in more depth, it is necessary to explore 'the focus of study' beyond 'the

frequency' of each topic. Therefore, the keyword list was analyzed to examine what and how algorithmic literacy has been studied in literacy education. In this case, considering that the same keyword was expressed in different terms for each study, the keyword list was reconstructed considering the meaning of each keyword. The list of frequent keywords for each topic is as follows.

Table 4. Frequent keyword list by topic

Topic	Frequent keywords	n	Keywords included (source)
①	Media power	4	Dezuanni (2021), Ignorance (Bhatt & MacKenzie, 2019), Algorithmic Personalization (Hobbs, 2020), Digital Divide (Ridley & Pawlick-Potts, 2021)
	Media literacy	3	Lee & Kwon (2020), Dezuanni (2021), Lee (2021)
	Platform	3	Lee (2021), Social media (Souza, 2018), Web 3.0 (Ptaszek, 2020)
	Advertisement	2	Hobbs (2020), Lee (2021)
	Digital literacy	2	Bhatt & MacKenzie (2019), Digital Engagement (Dezuanni, 2021)
	Disinformation	2	Dezuanni (2021); Fakenews, post-truth (Lee & Kwon, 2020)
②	Algorithmic literacy	5	Aleman et al. (2021), Bakke (2020), Head et al. (2020), Critical algorithmic literacy (Dasgupta & Hill, 2020; Jeong et al., 2022)
	Datafication	5	Jeong et al. (2022), Algorithmic surveillance and power (Dasgupta & Hill, 2020), Data exhaust (Head et al., 2020), Data ownership (Brandon, 2021), Privacy (Henderson et al., 2020)
	Algorithmic bias	4	Gardner (2019), Brandon (2021), Algorithmic justice (Head et al., 2020), Discrimination (Dasgupta & Hill, 2020)

	Media literacy	4	Valtonen et al. (2019), Hur & Jeong (2020), Jeong & Hur (2020), Jeong et al. (2022)
	Reflection	3	Bakke (2020), Hur & Jeong (2020), Self-discovery (Henderson et al., 2020)
	Information evaluation	3	Brandon (2021), Gardner (2019), Evaluation, Assessment (Jeong & Hur, 2020)
	Game learning	2	Aleman et al. (2021), Dasgupta & Hill (2020)
	Informationsearch	2	Search engines (Bakke, 2020), Search algorithm (Brandon, 2021)
	Informationlliteracy	2	Bakke (2020), Gardner (2019)
	Computational thinking	2	Hur & Jeong (2020), Jeong & Hur (2020)
③	Digital literacy	2	Marlatt & Sulzer (2021), Koenig (2020)
	Medal literacy	2	Brodsky et al. (2020), Critical media literay (Marlatt & Sulzer, 2021)
	Algorithm awareness	2	Brodsky et al. (2020), Algorithmic literacy (Koenig, 2020)
④	Social media	2	Glotfelter (2019), Swart (2020)
	News personalization	2	Swart (2021), Social media news (Ku et al., 2019)
	News use	2	Swart (2020, 2021)
	Audience	2	Glotfelter (2019), Swart (2021)
	Strategy	2	Content strategy (Glotfelter, 2019), Tactics of news use (Swart, 2021)
⑤	Critical algorithmic literacy	4	Cotter (2020), Algorithmic literacy (Lloyd, 2019), Critical posthuman literacy (Leander & Burriss, 2020), Attentional literacy (Pegrum & Palalas, 2021)
	Algorithmic culture	3	Lloyd (2019); Culture of digitality (Hong, 2022), Snack culture (Moon, 2019)

Agency	2	Agency (Leander & Burriss, 2020), Subjectivity (Hong, 2022)
Algorithm text	2	AI Text (Leander & Burriss, 2020), AI Algorithm-based text environment (Pyun, 2022)
Circulation	2	Leander & Burriss (2020), Network (Hong, 2022)

The frequent keywords of ②, which have the largest number of literature, were 'algorithmic literacy, datafication, algorithm bias, reflection, and information evaluation'. These frequent keyword lists imply that the negative problems caused by the algorithm are emphasized in ②. For example, 'Dataization' refers to the conversion of all actions of users into data on a digital platform (Jeong et al., 2022). This concept points out the phenomenon of indiscriminate collection and circulation of users' personal information in an online space and emphasizes their ability to engage in. Similarly, 'algorithmic bias' is a concept that represents a problematic phenomenon in which socio-cultural bias or discrimination factors are reproduced as algorithms intervene in the information search process (Gardner, 2019). In algorithmic environment, the ability to identify and deal with these biases is emphasized (Brandon, 2021).

Accordingly, in topic ②, educational discourse that fosters the ability to critically engage in problematic phenomena caused by algorithms is emphasized. In other words, topic ② emphasizes the education of algorithmic literacy, media literacy, computing thinking, information literacy, and 'reflection'. Reflection is a series of processes and abilities that "stop judgment" (Jeong & Hur, 2020) and record, analyze, and evaluate one's practice (Bakke, 2020). Accordingly, reflection can be said to be the content and method of education in itself.

On the other hand, the frequent keywords of ⑤ were 'critical algorithmic literacy, algorithm culture, agency (subjectivity), algorithm text, and circulation'. Keywords that are distinct from other catego-

ries are 'algorithmic text, algorithmic culture, circulation, and agency'. Considering that topic ⑤ focuses on examining the change in literacy environment, concept, and characteristics due to algorithms, the frequent keyword list suggests that ⑤'s focus is on "text and its environment". In other words, topic ⑤ emphasized that the emergence of a 'non-human agent', that is to say an algorithm, changed the text (Leander & Burriss, 2020; Pyun, 2022) and the media ecosystem from the production, consumption, and circulation of text (Cohen, 2018) and its influence became so common that the term 'algorithmic culture' was coinded (Lloyd, 2019; Moon, 2019).

Also, topic ⑤ points out that the 'value-biased' algorithmic culture threatens human agency (Lloyd, 2019). As the logic of the attention economy works and disinformation is indiscriminately circulated, it is concerned that human agents lose their identity and ability to act subjectively (Pegrum & Palalas, 2020). It is also concerned about the formation of 'algorithmic identities' made on the basis of surface and personal information (Leander & Burriss, 2020; Pyun, 2022), and the formation of "Automatisiertes Subjekt" (Hong, 2022) that only act passively as the algorithm leads. Topic ⑤ focuses on this point, emphasizing education that develops the ability to understand the changes caused by algorithms and to engage critically and subjectively.

The frequent keywords of topic ①, which emphasized that literacy education needs to change, include "media literacy, platform, advertisement, digital literacy, media education, and disinformation." The above keyword list suggests that ① is approaching algorithmic literacy in relation to media literacy and focusing on 'changes in traditional media literacy education'. For example, these studies pay attention to the fact that in an algorithmic environment, advertisements turn into 'target advertisement (personalized advertising)' (Lee, 2021), and furthermore becomes a 'propaganda' (Hobbs, 2020). They also focus on the problem of 'post-truth' caused by the indiscriminate circulation of disinformation (or 'fake news') (Dezuanni, 2021; Lee & Kwon, 2020) and new platforms such as the web 3.0 and social me-

dia-oriented platform environments (Lee, 2021; Ptaszek, 2020; Souza, 2018) based on biased and personalized algorithms.

And it points out the risk that the 'ignorance' of this change causes uncritical literacy practices such as 'pursuit of reputation' (Bhatt & MacKenzie, 2019) and also the problem of a new 'digital divide', which means "the gap between a class of people who can use algorithms and a class used by algorithms" (Ridley & Pawlick-Potts, 2021, p. 4). Topic ① points out these changes and emphasizes that existing media literacy education must be changed considering the influence of algorithms (Bhatt & MacKenzie, 2019; Dezuanni, 2021; Hobbs, 2020; Ptraszek, 2020; Ridley & Pawlick-Potts, 2021).

Finally, the topic ③ and ④ had the smallest proportion, with 3 studies and 4 studies respectively. This seems to be due to the fact that the perception and performance survey in educational study is generally conducted 'when it is judged that related educational and learning experiences have been sufficiently accumulated'.

The frequent keywords of ③ were 'digital literacy, media literacy, and algorithm awareness'. The studies in ③ points out that although the influence of algorithms intervening in information search and collection is quite large, the level of awareness of ideology inherent in search results is relatively low. Accordingly, it emphasizes the importance of enhancing understanding of algorithms and their platforms (Koenig, 2020; Marlatt, & Sulzer, 2021). In particular, it raised the urgent need for algorithmic literacy education by finding that users are well aware of the operation of algorithms on 'online shopping platforms' due to traditional media literacy education, but not on 'social media feeds' or 'search result pages' (Brodsky et al., 2020).

The frequent keywords of ④ were 'social media, news personalization, news use, audience, and strategy'. It indicates that algorithmic literacy has been mainly investigated in the 'news literacy' aspect. In other words, audience study has focused on studying news choices and habits of users in a social media environment in which algorithms filter and provide news (Ku et al., 2019), and exploring strategies to

appropriately cope with algorithmic filtering (Swart, 2020, 2021).

These studies emphasized that the algorithm experience is not immediately converted into algorithmic literacy and that algorithmic literacy varies depending on the context, so experience of and learning about algorithms should be done in various contexts (Brodsky et al., 2020; Marlatt & Sulzer, 2021; Swart, 2020).

3. Research methods and subjects

As a result of the analysis, there were 17 studies using the literature review, 16 studies using the qualitative method, and 2 studies using the quantitative method. There was no literature using mixed method.

The fact that there are many studies applying literature reviews and qualitative method suggests that literacy education is interested in theoretical consideration of algorithmic literacy and expanding understanding based on empirical evidence. As research is in its early stages, it is most important to have a thick theoretical and empirical basis for algorithmic literacy, which will be the foundation of educational discourse.

Specifically, in studies applying qualitative methods, there were 10 action research studies, 5 interview-based case studies, 1 observation-based survey study, and the proportion of action research was large. The fact that a lot of action research has been conducted seems to be related to the lack of educational discourse on algorithmic literacy. In order to revitalize educational discourse, many studies have been conducted to prove educational value by directly developing educational programs (Beveridge, 2017; Bhatt & MacKenzie, 2019; Brandon, 2021; Gardner, 2019; Henderson et al., 2020; Hur & Jeong, 2020; Jeong et al., 2022; Koenig, 2020; Marlatt & Sulzer, 2021) or platforms (Aleman et al., 2021).

The low proportion of quantitative research can also be interpreted in relation to the situation where relevant research achievements

have not been sufficiently accumulated. It is not easy to create a test tool in a state where there is not enough agreement on the concept, constructs, and specific characteristics of algorithmic literacy. In addition, the lack of theoretical or empirical evidence on programs and variables that effectiveness or influence relationship needs to be verified can also be a limiting factor for quantitative research. Also, due to the opacity of algorithms ('black box') that operating principles are not clearly known and the characteristics of algorithms that continue to 'evolve' (Swart, 2021) based on user data, it can be inferred that the proportion of studies which use quantitative methods is small.
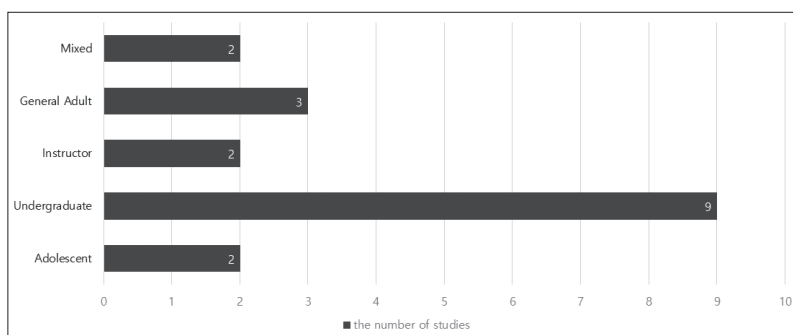

Figure 3. Number of studies by subject

Figure 3 shows the results of analyzing 18 research topics, excluding 17 literature studies that it is difficult to specify subjects. There were 9 studies conducted on 'undergraduates', followed by 3 studies on 'adults'. Swart's studies (2020, 2021) were the only case that the subjects were mixed (adolescent and undergraduate). The large number of studies for undergraduates is also related to the large proportion of action research.

In a situation where the educational discourse of algorithmic literacy has not been elaborated, there are many practical limitations to conducting research on adolescents (especially action research). On the other hand, since it is relatively easy to open new courses or

programs in universities, most of the research to develop new courses or programs seems to have selected undergraduates as the research subjects.

It is also worth noting that both 'undergraduates' and 'general adults' are 'adults'. This is related to the fact that there is a tendency to explain the acquisition or learning of 'algorithmic literacy' in literacy education based on 'folk theories'. According to this theory, users acquire knowledge, skills, and attitudes about algorithms through informal education, not through formal education. It is to acquire relevant knowledge while using and experiencing algorithmic platforms in daily life (Cotter, 2020; Head et al., 2020). In other words, even if users do not know the term algorithm, they are aware of the existence of the algorithm and have their own know-how to engage in it (Swart, 2021).

This empirical knowledge is related to the quantity and quality of experience on algorithmic platforms. From this point of view, it can be assumed that many studies have selected adults as subjects because adults are the group that is thought to have abundant high-quality experience in algorithm platforms. This tendency can be clearly confirmed through a qualitative study in which 'general adults' were selected as the subjects. In these studies, adults with rich understanding and experience of algorithmic platforms, such as those with experience in producing content to be posted on algorithmic platforms (Glotfelter, 2019) or influencers (Cotter, 2020), were selected as subjects.

4. Educational plan: Contents and teaching methods

All of the literature analyzed in this study are in the field of education. Therefore, studies that do not belong to topic ② also presented suggestions on educational plans in 'Discussion' or 'conclusion'. However, there were differences by a study, such as presenting both content and teaching methods or presenting only one. Accordingly,

the educational plan was divided into 'content' and 'teaching method'. Coding was conducted according to Table 1, and when several teaching methods were proposed in one literature, multiple coding was performed.

First, implications for 30 education contents were extracted from 35 studies. Contents were often presented in the form of activities that students can participate in or things that must be dealt with in education rather than in the form of learning elements. The contents trend is as shown in Figure 4.
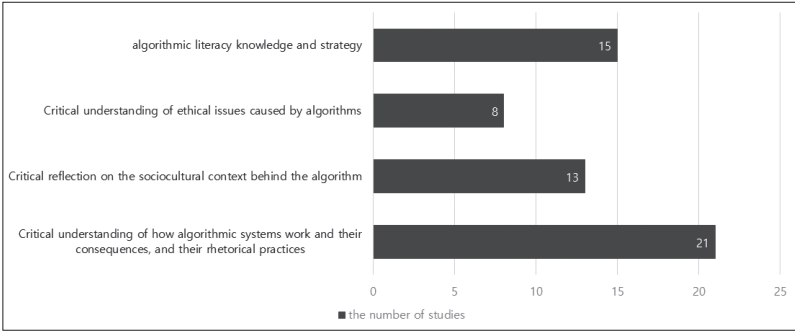

Figure 4. Number of studies by education content

As a result of the analysis, the contents for 'critical understanding of algorithm system operation and rhetorical practice' (21 studies) accounted for a large portion. This suggests that literacy education emphasizes understanding the algorithm system that searches for and selects information and sources beyond analyzing or evaluating content and sources of each information (Bakke, 2020), 'understanding of algorithm personalization that transforms user experience into data to predict his behavior' (Hobbs, 2022), and critical understanding of the phenomena it causes. In particular, these studies took the perspective of viewing the operation of the algorithm as an 'rhetorical practice' (Beveridge, 2017; Koenig, 2020).

This suggests that the content emphasized in literacy education

prioritizes the ability identify and critically engage to the ideology of the content recommended by the algorithm. Namely, literacy education content focuses on understanding that the expression of the algorithm (the process of producing results and the results) is value biased and rhetorical practice involving various intentions and developing a critical evaluation ability about expression of these algorithms.

In addition, it was found that a great deal of emphasis was placed on learning about algorithmic knowledge and strategies (15 studies), which are components of algorithmic literacy, and critical reflection on social, economic, and political contexts related to algorithmic systems (13 studies).

In the former, 'knowledge' includes understanding of algorithmic techniques such as 'Tracking, Attention engineering, and Content filtering' (Valtonen et al., 2019), the existence of algorithms as biased agent, rhetorical practices of algorithms, and an understanding of characteristics of the media environment and culture that have changed due to the algorithm (Hobbs, 2020; Koenig, 2020; Ku et al., 2019; Leander & Burriss, 2020; Lloyd, 2019; Marlatt & Sulzer, 2021). 'Strategies' include 'lateral reading strategy' (Brodsky et al., 2020) to overcome information bias, 'attention literacy' (Pegrum & Palalas, 2021) not the lose agency in an algorithmic environment in which the attention economy operates, 'rhetorical techniques and algorithmic imaginary' (Glotfelter, 2019), question strategies about algorithms and algorithmic phenomena (Leander & Burriss, 2020; Lee & Kwon, 2020) and critical reading strategies in an algorithmic environment (Hobbs, 2022; Pyun, 2022) to resist to 'algorithmic circulation' that influence user's choice and behavior.

In relation to the latter, it is worth noting that the scope and function of the sociocultural to be considered in algorithmic literacy education have been extended to the level of macro discourse. Specifically, in the literature, a critical understanding of the power that exists behind the algorithm and exerts influence is emphasized (Brandon, 2021; Gardner, 2019; Ptaszek, 2020). It also emphasizes the

understanding of knowledge practices in which knowledge is produced, sponsored, evaluated, and excluded by power (Bhatt & MacKenzie, 2019), and critical engagement to the dataveillance caused by algorithms (Brandon, 2021; Cohen, 2018; Hobbs, 2020). Also, the real practice of critical literacy is emphasized, such as knowing and reflecting on the entire political, economic, and sociocultural context surrounding algorithms (Jeong et al., 2022; Pyun, 2022). It is in this context that Cotter (2020) emphasized that users' critical algorithmic literacy cannot drive practical changes in the algorithm platform, but it has the possibility of bottom-up tools that can lead to institutional changes.

In 7 studies, contents related to critical understanding and reflection on ethical and moral issues raised in the algorithmic environment was presented. It emphasized a critical understanding of ethical and moral issues caused by algorithms, such as reproduction/representation of social prejudice by algorithms (Aleman et al., 2021; Dasgupta & Hill, 2020; Gardner, 2019; Head et al., 2020; Lee, 2021; Souza, 2018), information distortion and search bias by algorithm filtering (Beveridge, 2017; Brandon, 2021). The above educational contents clearly suggest that algorithmic literacy in literacy education is treated as sociocultural practice and situational practice, not computer or programming technology.

On the other hand, 20 teaching methods were extracted from 35 studies. The most frequently mentioned teaching method was an activity-oriented method in which students directly "experience" the design and decision-making process of algorithms (8 studies). This category includes methods for students to set recommendation criteria for content while participating in a play that assumes they have become an algorithm developer (Hur & Jeong, 2020; Jeong et al., 2022), and methods for designing algorithms based on game learning (Aleman et al., 2021; Dasqupta & Hill, 2020; Gardner, 2019; Henderson et al., 2020). These teaching methods allow students to understand the systems of algorithms and learn about strategies to engage to algorithms

and even ethical and social issues related to algorithms by directly experiencing a series of processes to design and operate algorithms.
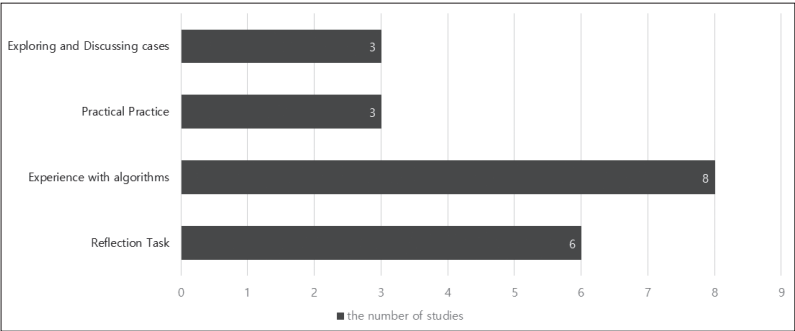

Figure 5. Number of studies by teaching method

In the 3 studies, an teaching method of acquiring knowledge and strategies by practicing literacy on an actual algorithm platform was presented. This method is similar to "experience" in that it emphasizes students experiencing algorithm platforms directly, such as 'analyzing hashtags or memes' and 'analyzing search results' (Gardner, 2019; Marlatt et al., 2021), and allows students to systematically practice algorithmic literacy that varies depending on the situation while encountering more diverse algorithm platforms (Swart, 2021). However, the "experience" teaching method differs in that it is an teaching method that promotes students' understanding of the algorithm's operating system or related issues while directly playing the role of designers, developers of algorithms (Dasgupta & Hill, 2020).

On the other hand, 'reflection tasks' are also teaching methods suggested in many studies (6 studies). This is related to the approach of folk theory that users form empirical knowledge about algorithms in the process of using algorithm platforms. In this theory, the algorithmic knowledge that the user already has is considered a useful learning resource (Head et al., 2020; Swart, 2021). Specifically,

educational activities such as recording, analyzing, evaluating, and reflecting on one's search practices (Bakke, 2020), constructing one's own interpretation of algorithms by reflecting on platform-specific algorithms (Cotter, 2020), or writing a media journals (Koenig, 2020) are included. This teaching method allows students to discover and learn algorithm knowledge and strategies by reflecting on their activities and experiences with the algorithm.

Teaching methods similar to 'reflection tasks' include 'case exploring and discussing cases' (3 studies). This teaching method includes reading an article about a problem or issue raised by an algorithm (Beveridge, 2017), watching a video (Brandon, 2021), or exploring an example (Brandon, 2021) and then having a discussion. This teaching method is a variation of the reflection task in that it emphasizes the analysing algorithm itself and constructing students' own thoughts and logic on algorithmic issues through their implicit and empirical knowledge of the algorithm.

IV. Discussion and Conclusion

Based on the above results, some suggestions for a follow-up studies are as follows.

First, research topics on algorithmic literacy should be diversified. The existing topics were focused on emphasizing the necessity of algorithm literacy education or suggesting educational plans. In order to actualize educational discourse, it is important to collect empirical data from various educational subjects. Therefore, topics that closely explore the perceptions or performances of students and educators should be actively dealt with. In addition, study should be conducted to conceptualize the meaning of algorithmic literacy from the perspective of literacy education and to investigate its construct. A well-founded conceptual research can contribute to detailing and validating educational content and methods.

Second, it is necessary to expand research methods and research subjects. Regarding the research method, in particular, research applying the quantitative method should be actively attempted. In order to prepare an effective educational discourse, the process of statistically verifying the effectiveness of the contents and teaching methods and examining the possibility of generalization should be accompanied. At the same time, literature research and qualitative research should continue to be actively conducted. As mentioned above, the concept of algorithmic literacy is fluid and constantly evolving. Therefore, research should be actively conducted to secure theoretical and empirical evidence data that forms the basis of algorithmic literacy education.

In terms of subjects, it is necessary to expand the scope of research subjects in order to construct a practical educational discourse. In particular, research on adolescents such as elementary, middle, and high school students should be actively conducted. In the same context, research on Korean youth with high exposure and experience to algorithmic environments such as SNS due to high smartphone penetration rate should be actively conducted. Effective educational discourse can be prepared only when detailed observation and investigation of youth's perception and performance of algorithmic literacy are supported.

In addition, research on (pre-service) teachers should be actively conducted. As mentioned earlier, existing studies have emphasized empirical knowledge or taken a folk theory approach in relation to the learning path of algorithmic literacy (Cotter, 2020; Swart, 2020, 2021). Accordingly, cooperative learning with colleagues who have a lot of resources for algorithms, that is, 'peer-to-peer learning' education (Head et al., 2020), was presented as an effective educational method. However, this is only a stopgap. In order to prepare an educational discourse on algorithmic literacy, teacher research should be actively conducted to support teachers' expertise in algorithmic literacy education.

Third, considering the situation of school education in Korea, research to refine and actualize the contents and teaching methods of algorithm literacy education should be conducted. This is a part that needs to be preceded in order to apply foreign cases appropriately to Korean schools. Specifically, discussions on what knowledge and strategies need to be learned in relation to algorithmic literacy and what abilities should be developed to cope with algorithm issues or problematic phenomena should be conducted in earnest.

In particular, research is needed to review the scope of educational content. For example, a detailed study should be conducted on which algorithm knowledge or skills to include as the content of literacy education and to what level the social, economic and political context surrounding algorithms will be dealt with in adolescent literacy education. Research related to this scope setting needs to be done urgently in that it is related to elaborating the educational contents of algorithmic literacy and examining the feasibility of algorithmic literacy education in school education.

Regarding teaching methods, it is necessary to develop a teaching and learning methods in consideration of the domestic school environment. To this end, first of all, research should be conducted to apply educational programs to Korean students and verify their effectiveness. In addition, study on how to utilize teaching methods such as 'reflection tasks' appropriately for the domestic situation should be conducted. In particular, research is needed to consider how to subdivide and hierarchize tasks by school level and to find ways to settle down on the school education based on actual application cases.

In this study, in order to examine domestic and foreign literature, literature was collected and extracted focusing on whether specific keywords were included. As a result, there may be limitations in capturing the terrain of actual research intact. Nevertheless, this study is meaningful in that it is the first attempt to comprehensively review domestic and foreign literature and to examine how algorithmic literacy discussions are developing in literacy education. Based on this

study, it is hoped that research related to algorithmic literacy in literacy education will be activated and the educational discourse of algorithmic literacy will begin in earnest.

REFERENCES

Aleman, E., Nadolny, L., Ferreira, A., Gabetti, B., Ortíz, G., & Zanoniani, M. (2021). Screening bot: A playground for critical algorithmic literacy engagement with youth. In *Extended Abstracts of the 2021 Annual Symposium on Computer-Human Interaction in Play*, 198-202.

Bakke, A. (2020). Everyday Googling: Results of an observational study and applications for teaching algorithmic literacy. *Computers and Composition, 57*, 102577.

Beveridge, A. (2017). *Writing through big data: New challenges and possibilities for data-driven arguments* [Forum], Composition Forum 37.

Bhatt, I., & MacKenzie, A. (2019). Just Google it! Digital literacy and the epistemology of ignorance. *Teaching in Higher Education, 24*(3), 302-317.

Brandon, E. (2021). Empowering students with digital literacy skills. *Change: The Magazine of Higher Learning, 53*(6), 35-41.

Brodsky. J. E., Zomberg, D., Powers, K. L., & Brooks, P. J. (2020). Assessing and fostering college students' algorithm awareness across online contexts. *Journal of Media Literacy Education, 12*(3), 43-57.

Cohen, J. N. (2018). Exploring echo-systems: How algorithms shape immersive media environments. *Journal of Media Literacy Education, 10*(2), 139-151.

Cotter, K. M. (2020). *Critical algorithmic literacy: Power, epistemology, and platforms.* Michigan State University.

Dasgupta, S., & Hill, B. M. (2020, August). Designing for critical algorithmic literacies. *arXiv preprint.* arXiv:2008.01719

Dezuanni, M. (2021). Re-visiting the australian media arts curriculum for digital media literacy education. *The Australian Educational Researcher, 48*(5), 873-887.

Gardner, C. C. (2019). Teaching algorithmic bias in a credit-bearing course. *International Information & Library Review, 51*(4), 321-327.

Glotfelter, A. (2019). Algorithmic circulation: How content creators navigate the effects of algorithms on their work. *Computers and Composition, 54*, 1-14.

Head, A. J., Barbara, F., & Margy, M. (2020). *Information literacy in the age of algorithms: student experiences with news and information, and the need for change.* Project Information Literacy.

Henderson, M. J., Shade, L. R., & Mackinnon, K. (2020, October). Every click you make: Algorithmic literacy amd the digital lives of young adults. *AoIR Selected Papers of Internet Research.* https://doi.org/10.5210/spir.v2020i0.11233

Hobbs, R. (2020). Propaganda in an age of algorithmic personalization: Expanding literacy research and practice. *Reading Research Quarterly, 55*(3), 521-533.

Hong, S. S. (2022). An educational consideration on the subjectivity in a culture of digitality. *Journal of Education & Culture, 28*(2), 543-562.

Hur, K. & Jeong, H. S. (2020). Developing algorithm for evaluation of information and procedure of critical thinking in media literacy education. *The Journal of Education, 40*(4), 287-304.

Jeong, H. S., Oh, Y. J., & Kim, A. (2022). Critical algorithm literacy education in the age of digital platforms: Teaching children to understand YouTube recommendation algorithms, In *Learning to Live with Datafication* (pp. 153-168). Routledge.

Jeong, H. S. & Hur, K. (2020). Incorporating computational thinking into media literacy education for critical thinking. *Journal of Korean Culture, 48*, 105-128.

Kim, S. Y., Park, J. E., Seo, H. J., Lee, Y. J., Jang, H. B., Son, H. J., & Shin, C. M. (2011). *NECA's guidance for undertaking systematic reviews and meta-analyses for intervention*. National Evidence-based Healthcare Collaborating Agency.

Koenig, A. (2020). The algorithms know me and I know them: using student journals to uncover algorithmic literacy awareness. *Computers and Composition, 58*, 102611.

Ku, K. L., Kong, Q., Song, Y., Deng, L., Kang, Y., & Hu, A. (2019). What predicts adolescents' critical thinking about real-life news?. *Thinking Skills and Creativity, 33*, 100570.

Leander, K. M., & Burriss, S. K. (2020). Critical literacy for a posthuman world: When people read, and become, with machines. *British Journal of Educational Technology, 51*(4), 1262-1276.

Lee, J. W. (2021). A study on the media literacy education method using media development process and advertisement. *Korean Journal of Converging Contents, 3*(1), 23-39.

Lee, Y. J. & Kwon, E. (2020). Fake news and FocI of literacy education in the Post-truth Era. *The Korean Journal of Literacy Research, 11*(6), 101-134.

Lloyd, A. (2019). Chasing Frankenstein's monster: Information literacy in the black box society. *Journal of Documentation*.

Marlatt, R., & Sulzer, M. A. (2021). Illuminating the dark side: A typology for preservice ELA teachers engaging in ideologies of digital texts. *E-Learning and Digital Media* 18(3), 226-250.

Moon, S. J. (2019). Children's Snack-culture Trend and Media Protection Plan. *DongGwang* 114, 146-164.

Pegrum, M., & Palalas, A. (2021). Attentional literacy as a new literacy: Helping students deal with digital disarray. *Canadian Journal of Learning and Technology* 47(2).

1-18.

Ptaszek, G. (2020). Media education 3.0? How big data, algorithms, and AI redefine media education. *The Handbook of Media Education Research*, 229-240.

Pyun, J. Y. (2022). Fragmentary thoughts on critical literacy in an AI algorithm-based text environment. *The Journal of Korean Language and Literature Education*, 79, 37-76.

Ridley, M., & Pawlick-Potts, D. (2021). Algorithmic literacy and the role for libraries. *Information Technology and Libraries, 40*(2).

Souza, R. R. (2018). Algorithms, future and digital rights: Some reflections. *Education for Information* 34(3), 179-183.

Swart, J. (2020, October). Tactics of algorithmic literacy: How young people understand and negotiate algorithmic news selection. AoIR Selected Papers of Internet Research. https://doi.org/10.5210/spir.v2020i0.11342

Swart, J. (2021, April). Experiencing algorithms: How young people understand, feel about, and engage with algorithmic news selection on social media. *Social media+ society, 7*(2), https://doi.org/10.1177/20563051211008828

Valtonen, T., Tedre, M., Mäkitalo, K., & Vartiaindn, H. (2019). Media Literacy Education in the Age of Machine Learning. *Journal of Media Literacy Education, 11*(2), 20-36.

ABSTRACT

A Systematic Review of 'Algorithmic Literacy' in Literacy Education

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This study analyzed the existing research results using a systematic review to outline the research topography of the field of literacy education on algorithmic literacy. Although a related studies are not sufficiently accumulated, a systematic review was conducted to derive meaningful implications for algorithmic literacy education by examining existing literature based on a more valid methodology. Accordingly, the finally extracted 35 studies were analyzed focusing on the publication and definition trends, research topics and keywords, research methods and subjects, and educational plans (contents and teaching methods). Based on the above analysis results, implications for the direction and point of research on algorithmic literacy in future literacy education were suggested.

KEYWORDS Algorithmic literacy, Systematic review, Literacy education, Literacy research