International Journal of Trend in Scientific Research and Development (IJTSRD)
Volume 9 Issue 6, Nov-Dec 2025 Available Online: www.ijtsrd.com e-ISSN: 2456 – 6470

A Systematic Literature of Gender, and Science Technology Curriculum for Developing Countries Higher Education

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ABSTRACT

Scientific literacy which helps individuals incorporate relevant scientific concepts and processes in personal decision making is increasingly emphasized in educational curricula as a means of preparing citizenry around the world for the role they must play in sustainable development of their countries. In order to cover the diverse concepts explored in this work, systematic narrative review methodology was adopted. Relevant literature was sourced from Web of Science and ERIC database, and screened following the PRISMA method. The final corpus was 51 manuscripts published between January 2012- Dec 2022. The review proposed was tabulated and categorized into three thematic concepts: science literacy information, gender knowledge domain, and curriculum issues in Africa. We recommend review of curricula emphasizing science-society nexus, development of relevant educational policies and encouragement of citizen collaborative participation with the goal to enhance the quality of life in Africa through research, technology and innovation.

KEYWORDS: *Science Literacy; information and Communication; Gender; Curriculum; Higher Education.*

How to cite this paper: Tetteh Terrence Thomas | Baiden Maame Efua Bentsiwah | Ayivor Bernard | Michael Akwesi Afram "A Systematic Literature of Gender, and Science Technology Curriculum for Developing Countries Higher Education" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-9 | Issue-6, December 2025, pp.871-891, URL: www.ijtsrd.com/papers/ijtsrd99973.pdf

IJTSRD99973

INTRODUCTION

Countries around the world are increasingly becoming Knowledge Economies which depend more on innovative intellectual resources of citizens than on natural resources (Edvinsson, L., et al.,2022). Across the world, higher education institutions (HEIs) are key sources of creation and dissemination of intellectual resources (Dollinger et al., 2018). Due to current global challenges, they are continually striving to deliver knowledge through comprehensive curricula which sufficiently cover relevant scientific information as a means of strengthening science-society nexus (Lakomý et al., 2019). This trend is a survival strategy as people everywhere seek innovative ways of combatting the impact of global challenges within their domains. Therefore, for Africa to keep up with projected sustainable development, there is need for scientific literacy which is accessible to all irrespective of gender or other differing characteristics.

The term "scientific literacy" is a contentious concept, especially when it is used in school curricula and it can be defined as an acquaintance with scientific knowledge and technology and other science educational fields (Lelliott, 2014). In a continent like Africa where socio-economic background is relatively low, effecting knowledge expansion in scientific literacy domain through curriculum review is capable of having substantial ripple effect in elevation of socioeconomic background of people. Science literacy differs depending on socioeconomic background of each nation, and research has shown that literacy level correlatively affects the quality of life and job opportunities available for an individual (Egbo, 2000). People without formal education are referred to as "illiterate" and those with primary education are referred to as "literate" (Smith-Greenaway, 2015).

From the authors' point of view, in the 21st century, the knowledge about science and its application to human life is like blood in the human artery. The knowledge about science otherwise known as science literacy has led to the invention and modification of certain machinery and equipment from manual operational methods to automatic methods. A lot of scholars have lent their voices on the term science literacy. Scientific literacy is of comprehensive sciences and the ability to implore scientific knowledge to impact the society through availability of science tools and achievements (Lederman et al. 2002; reviewed in Norris and Phillips 2003). Majetic & Pellegrino (2014), describe scientific literacy as having the basic conceptual knowledge about science and principles of science application in our inquiry and the role science plays in our routine life. Also, the measure of literacy seems to have encompassed reading and writing extending widely into the intertwining of technological skills and cognitive skills to function as a citizenry in the science world (Miller 2012 a 19). This extent in coverage of literacy makes for a critical view in scientific literacy toward the professional and continuous training of educators and school curriculum. In the works of (Juan et al., 2018), the scientific attitude in the school revolves around school culture, the culture of the school depends solely on the curriculum and teacher teaching practices.

Recent estimates of Africa's population are placed at about 1.3 billion people, and an annual growth rate of 2.7%, including vibrant youthful human resources composed of 75% under the age of 25 years (International Labour Organisation, 2018;UN DSD, 2017). The aspiration enshrined in Africa Agenda 2063 stipulates the pursuit of "A prosperous Africa based on inclusive growth and sustainable development (African Union, 2021)." Just like elsewhere in the world, in order to facilitate the attainment of that aspiration and to raise the socioeconomic background of Africa, scientific literacy must move beyond rhetoric and scientifically invest and research to improve human and social capital through an integrated education curriculum on science, technology, and innovation.

As mentioned earlier, Africa can be categorized as having a relatively low socio-economic background. For instance, a comparative study between US and Kenya reported that science literacy is low in Africa (Martinez. et al-2015). There are a host of factors that have been identified as causes of this backward trend in science literacy Africa. Among other things in Africa, there is a problem of the negative attitude of students towards science (Juan 2017), security challenges, inadequate science laboratories, poor funding, inadequate teacher quality and teaching methods (Margaret,2021), manpower development, and inefficient curriculum design (Ojimba ,2013). The curriculum is very essential for the development of science literacy in Africa. Corroborating this idea in South Africa, the science curriculum has been promoted and implemented as part of the natural science curriculum (Lelliott, 2014). In another instance, culture as a major concern in Africa curricula, Babaci-Wilhite (2017) raised an important issue faced by the inquiring-based learning in Africa and the study emphasizing local knowledge and using local languages which symbolizes culture as a right-based approach to science literacy has the potential to improve learning.

In addition, according to African Union, (2021), numerous sources of information within the AU Science, Technology and Innovation Strategy for Africa (STISA) has observed that science, technology, and innovation being at the epicenter of African development calls for improvement with emphasis on the effect of sciences in diverse sectors including agriculture, energy, environment, health, infrastructure improvement, mining, safety and water amongst others. As part of inclusive coordinated efforts to expand the focus of Innovative education at all levels of education, it becomes imperative that stakeholders, governments, institutions, and industries collaborate for scientific and innovative curriculum reoriented and equipped to meet the contemporary needs of Africa human resources. The modus operandi mutually reinforces STISA pillars on providing favorable environment for science technology and innovation (STI) in Africa. Achievable through TVET continental strategies designed for nations policies across Africa. Therefore, the prerequisite for successful national policies: upgrading and utilizing researches from national higher institutions, upgrading research infrastructure, collaborative network of experts, professionals, and technical competencies, enhancing entrepreneurial development and innovation, as well as providing the space to innovate.

Another important point was raised by the Organization for Economic Co-operation and Development [OECD] (2016) in their definition of science literacy. "Scientific Literacy" as the ability of citizens to reflect on science-related matters scientifically" (p. 22). This process of reflection can be viewed in three basic ways (1) ability to clarify science-related matters scientifically, (2) Ability to evaluate and design science inquiry, and (3) ability to analyze data and evidence scientifically. Obviously,

the citizen referred to by the OECD here comprises of male and female citizens. Over time, theory and practice have been applied to ensure inclusion of all citizens as a means of harnessing the potential possessed by all for the good of all. According to (Subramaniam, Ginorio, and Yee 1999) in Fuselier et al (2015), feminist theorists have not rested in establishing the relationship between female and natural sciences. The feminist described the current state of the relationship as "distrustful" and the contributions of science to meet female's quest in life questionable at best. The under-representation of females in sciences especially in the developing countries has become a source of concern and has resulted in slowing down the economic development of many nations (Mathew, R. V., & Panchanatham, 2018).

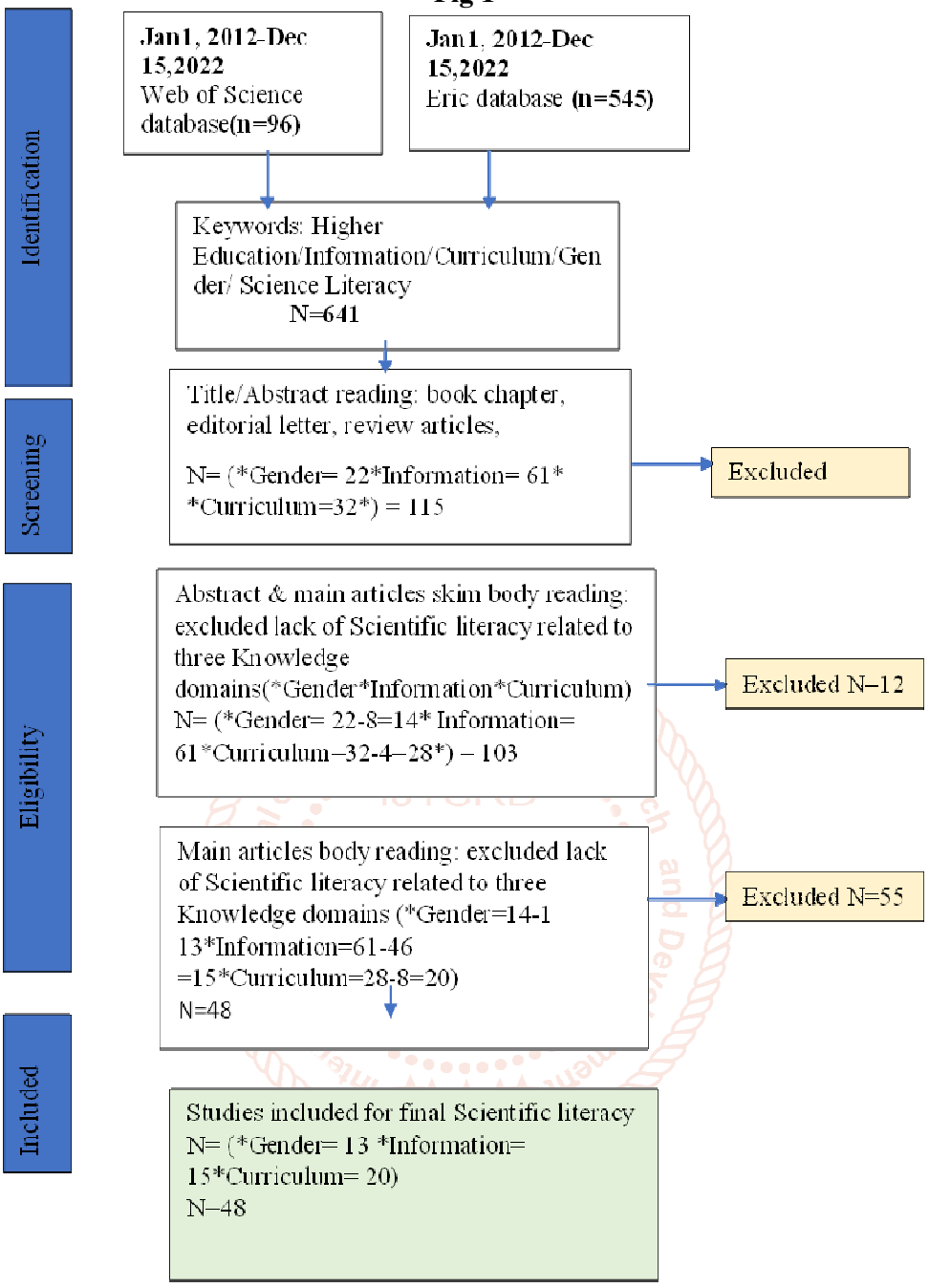
In order to further explore the diverse aspects of the above introduced concepts with respect to how science literacy in curriculum, information, and gender knowledge domains can be improved in Africa, the Education Research Group of the Organization of African Academic Doctors (OAAD) set out to learn the following from existing literature and discuss possible ameliorative actions: i) status of science literacy in Africa and the strategies employed in improvement of female inclusion in science literacy, ii) what are the scientific information and communication processes available for enhancement of scientific literacy in Africa? iii) status of science literacy in the curriculum domain and impact on higher education development and what processes might be involved in different approaches and implementations of scientific literacy curriculum knowledge domain reflecting on other continents with better or higher socio-economic background approaches?

Method

A systematic narrative review methodology was used to answer the research questions because it is the most appropriate method for covering extensive subjects (Collins and Fauser, 2005). In other to ensure that the review of this literature is in line with the guideline and standard of a systematic review set by OAAD and in accordance to providing answers to the aim of this study we choose a systematic review approach which according to Collins & Fauser, 2005 is best suited for comprehensive topics. Some criteria were set as guides for inclusion and exclusion of relevant literature. These guides include; articles which do not conform with the keywords, articles published in other languages, original research reviews or opinions were also been excluded from this review, both qualitative and quantitative manuscripts were included.

In this research, the first step was the collation of the method from two major databases "ERIC &Web of science" using the keywords ". (((ALL= (Higher education*)) AND ALL=(information*)) AND ALL=(curriculum*)) AND ALL=(gender*)) AND ALL= (science literacy*). In the second step, the team was divided into three sub-groups of Knowledge domains namely "Gender, Information, and Curriculum". Each group in their respective group work as a team on the Prisma process and later got N=51 as the studies final included for Scientific literacy of the three knowledge domains, the 51 studies was analyzed, discussed, drawn-out conclusions and provided necessary recommendations.

Fig 1



Findings

The findings for the systematic review are subdivided into three sub-groups as shown in table 1,2 &3.

A. How science literacy in various domain can be improved in Africa and the strategies to be employed to improve female inclusion in science literacy

Table1: A tabulated analysis on gender review

S/N	Authors	Article name	Country	Type of study	Improvement	Gender/ Population	findings
1	Antonio Campos-Sánchez Juan et, al. (2014)	Motivational component profiles in university students learning histology: a comparative study between genders and different health science curricula	Spain	quantitative	Enhance their learning process. Understanding their motivational process will better help them regulate their scientific learning behavior in histology.	367 first-year male and female medical students	The findings show that students in pharmacy, dentistry, and medicine have different motivational profiles when it comes to learning histology.

2.	Ama Otwiwah Adu-Marfo and Isaac Kofi Biney	Women and Distance Education: Experiences From The University Of Ghana Distance Education Programme	Ghana	Qualitative	Providing female students with technological and instructional assistance	15 female students	The study reveals that there are still some gender differences in completely accepting technology as a study tool.
3.	Carina S. González-González et,al (2020)	Strategies to introduce gender perspective in Engineering studies: a proposal based on self-diagnosis	Spain	Mixed method	Curriculum content and methods need to be redefined in order to be more equitable.	(12 professors) 4men, 8 women	According to the survey, only 0.1 percent of projects established in the last ten years include the phrase gender in the title or keywords, and only nine projects with the keyword gender have been developed in the last five years.
4	EZGI PEHLIVANLI-KADAYIFCI* (2019)	Exploring the Hidden Curriculum of Gender in Engineering Education: A Case of an Engineering Faculty in Turkey*	Turkey	Qualitative	present opportunities to modify dominant masculinity, which could be rebuilt through new university conceptualizations.	16) 8 engineering students and 8 faculty members	The findings demonstrated that women face a number of disadvantages as a result of institutional systems that place a premium on specific roles, while persons in engineering education learn to overlook such biases that favor the dominant ideal types.
5	Dragica Vujadinović, PhD* Nevena Petrušić, PhD* (2017)	Gender Mainstreaming In Legal Education In Serbia: A Pilot Analysis Of Curricula And Textbooks	Serbia	Qualitative	establishing gender action plans for all higher education institutions, including law faculties to mainstream gender issues.	textbooks	according to the study, gender-sensitive techniques are completely absent from curricula and texts.
6.	Natalija Mazeikiene and Lithuania Egle Gerulaitiene 2017)	Gendered Learning Biographies: Becoming A Teacher In Multicultural Education	Norway	Qualitative	enhance intercultural competency and raise cultural awareness among research participants, which influenced their educational and career paths.	14 male and female teachers	The findings demonstrated that learning as a lifetime process is closely tied to social identities (particularly gender) and the relationship between public and private, the relationship between employment, family, and learning, and so on.
7.	Liga Paura, Irina Arhipova (2016)	Student Dropout Rate In Engineering Education Study Program	Latvia	quantitative		953 Agricultural students	During the first academic year, 26 percent of students leave the institution on average, with the engineering science faculties having the highest dropout rate of 47.6% in 2012-2014.

8	Cristina Varsavsky a (2014)	Perceptions of Science Graduating Students on their Learning Gains	Australi a	Quantitativ e	Improve teaching and assessment practices	400 undergradu ate science students	Female students assigned greater importance to oral communication, scientific writing, teamwork, and ethical thinking, and saw greater inclusion of communication, teamwork, and ethical thinking skills. Male students reported greater confidence in scientific content knowledge and quantitative skills; female students assigned greater importance to oral communication, scientific writing, teamwork, and ethical thinking, and saw greater inclusion of communication, teamwork, and ethical thinking skills.
9.	Cassie Majestica & Catherine Pellegrino a 2014)	When Science and Information Literacy Meet: An Approach to Exploring the Sources of Science News with Non-Science Majors	UK	Qualitative	assisting non-science students in the development of science and information literacy	1500 students from women liberal art college	In the study, Students have anecdotally reported that the abilities learned here can be applied to interpreting media reporting from various academic subjects, particularly social science.
10	Yuan-Hsuan Lee	Scripting to enhance university students' critical thinking in flipped learning: implications of the delayed effect on science reading literacy	Taiwan	experiment al	In flipped learning environments, to improve students' critical thinking and self-directed learning.	85 Taiwanese university	According to the findings, providing structure for university students in flipped collaborative science reading had a long-term impact on their learning, as they were more likely to think about the questions discussed with partners, try to find answers to the questions, discuss reading content findings with friends, or reread the shared online note or article.
11	Brittany Ziegler* and Lisa Montplaisi	Student Perceived and Determined Knowledge of Biology Concepts in an Upper-	US	Experiment al	Improving students' ability to interpret their knowledge more	2 sets of students	In the posttest, there was a substantial difference in perception and

	r† (2014)	Level Biology Course			properly		determined knowledge alignment between males and females, with females having a more correct impression of knowledge. This research shows that there are gaps between what students believe they know and what they actually know.
12	Linda Fuselier (2015)	Teaching scientific literacy in introductory women's studies course: a case study in interdisciplinary collaboration	USA	Mixed method	faculty participants' successful curricular change and academic boundary crossing	186 female students	Discipline distinctions provide challenges, as does the provision of a space for interdisciplinary work and proof of boundary-crossing. Student participants demonstrated greater prior knowledge of Women's Studies content than of the nature of science, but they also demonstrated progress in the areas of scientific literacy and understanding of challenges affecting women in science careers. The inclusion of a female scientist in the learning module improved student knowledge of science topics.
13	Gnawali et. al (2022)	Access, Efficiency, Inconvenience, and Scarcity as Issues of Online and Distance Learning in Higher Education	Nepal	Quantitative	online and distance learning (ODL) help working teachers and professionals to continue higher education and professional development	(57 male and 14 female) postgraduate students	participants' views about scarcity were significantly different across their gender (male and female)

Table 1 shows that science literacy has been a source of concern as it is being discussed mostly across Europe in countries like Spain, Turkey, Serbia, Latvia, Australia, the UK, and Norway. In the Americas and Europe science literacy has also attracted researchers' attention even though they are seen as developed continents. Asia (Taiwan) has one article published that is science literacy-related, while Ghana published on women and distance education. From the findings of the articles under review, the female has not fully participated in science literacy compared to their male counterparts.

The articles reviewed, highlighted some of the discrepancies in male and female inclusion and participation in science courses. Antonio Campos-Sánchez Juan et, al. (2014) Explored the motivational component responsible for students' interest in basic science. There was no significant difference among gender, however, the study shows that motivational profiles differed among pharmacy, dentistry, and medical students. Ama Otwiwah &Biney (2017) explored the experiences of women's online education. The study reveals that there are still

considerable gender discrepancies in the use of technology as a study tool. They recommend that by providing technological support to female students, the digital divide between males and females can be reduced. Women's use of technology should be increased to facilitate their online learning and also learning technologies should be integrated into the curriculum. Kadayifci (2019) explores the untapped curriculum of gender in engineering studies. He reveals that women in engineering education experience several disadvantages because of institutional structures. It was suggested that providing possibilities to reshape dominant masculinity might be reconstituted through new conceptualizations of universities. Gender Mainstreaming in Legal Education, a study by Dragica and Nevena (2017), reveals a complete lack of gender-sensitive techniques in curricula and textbooks. They emphasize the significance of all higher education institutions developing gender mainstreaming action plans. Cristina (2014) found that male students were more confident in science information, while female students placed a higher value on communication, teamwork, and ethical reasoning. Hence there is a need to improve teaching and assessment and successful transformation of the curriculum to target the improvement of female's scientific knowledge.

Table 2: A tabulated analysis on information review

A. scientific information and communication processes to enhance scientific literacy in Africa

Table

Author	Population design	Study design	Findings	Year	Country	Topic
1. Podgornik, B. B., Dolničar, D., & Glažar, S. A. [1]	493 of university student	Quantitative	The findings revealed a moderately significant positive association between students' SL and IL.	2016	Slovenia	Does the Information Literacy of University Students Depend on Their Scientific Literacy
Monaghan-Geernaert, P.[2]	Freshmen, Sophomores; Junior and senior students completed the study Total 106	Quantitative	The results indicate students found the video podcasts to be quite useful in discovering and reading the articles.	2019	USA	Flipping the Classroom to Teach the Evaluation of Research Articles and the Development of Scientific Literacy
Lantz, C., & Dempsey, P. R[3]	focus groups with 23 second-and third-year biology students	Qualitative with focus group discussion	indicated progressive advances in information literacy (IL) abilities and attitudes required for individuals to enter the community of scientific practice as outlined in the ACRL Framework for Information Literacy in Higher Education.	2019	USA	Information Literacy Strategies Used by Second- and Third-Year Biology Students
Majetic, C., & Pellegrino, C. [4]	Student n-86	Quantitative Cohort	More moderate advances in science literacy abilities were reported, indicating future areas of instructional attention.	2018	Indiana	Building Information Literacy Skills Using Science News Media: Evidence for a Hands-On Approach
Fuselier, L., Murphy, C., Bender, A., & Creel Falcón, K [5]	four-year university in the Midwestern USA n-6500.	case study	Among collaborators, we discovered evidence of discipline-based barriers to transdisciplinary and disciplinary border bridging.	2014	USA	Teaching Scientific Literacy in an Introductory Women's Studies Course: A Case Study in Interdisciplinary Collaboration
ÖZTÜRK, N., Altan, E. B., & TÜRKOĞLU, A. Y.[6]	13 pre-service science teachers' (PSTs') n-11 female,n-3 male	Qualitative case study	re-sciences teachers promote scholarly conversations on social media rather than just video chatting. According to the	2021	TURKEY	Discussing Socio-Scientific Issues on Twitter: The Quality of Pre-Service Science Teachers' Arguments

			findings, information on Twitter should be used to establish an informal learning environment for students and instructors. For science literacy partnerships, social media technologies are information-driven.			
Anilan, B., Atalay, N., & Kiliç, Z [7]	86 third-grade candidate science teachers were selected as the study group. Central Anatolia	Quantitative and open-ended question	Science teachers have difficulty linking scientific findings. As a result, science instructors require an understanding of scientific activities and scientific applications to daily routines.	2018	Central Anatolia.	Teacher Candidates' Levels of Relating the Scientific Knowledge to Their Daily Lives
Morin, O., Tytler, R., Barraza, L., Simonneaux, L., & Simonneaux [8]	Socio-scientific issues (SSIs) French & Australian pre-science teacher online discussion & development of the wiki. Cross-cultural encounters were found to improve thinking. Cross-cultural contacts can improve science literacy.	Online cross-cultural discussion among science teachers. Qualitative approach	The cross-cultural interchange improved the level of thinking, and we discovered the role of context in framing reasoning quality.	2013	Australian	Cross-Cultural Exchange to Support Reasoning about Socio-Scientific Sustainability Issues
C. Selepe, L. L. Lekena	Data collected comprised of responses from 11615 first-year students over three years (2014; 2015; and 2017)	Longitudinal survey investigation. Findings reveal scientific literacy must change in line with 21st Century students; culture of networking and communication in a digital terrain.	Although parts of critical reflective teaching are included in the Central University of Technology (CUT) teacher training curricula, students are unaware that critical reflection and reflective teaching are an intrinsic component of the theory and practice of teaching and learning.	2018	South Africa	Mapping first-year students' concerns to the needs of the 21st-century learner: a case study of a university of technology in South Africa
Archila, P. A., Molina, J., Danies, G., de Mejía, A. M. T., & Restrepo, S.[9]	115 undergraduates (62 females and 53 males) in Colombia	A mixed-methods approach	The findings indicate that the TLS can be an excellent starting point for showing undergraduates some of the various ways in which news items foster public (mis)understanding of science and, hence, enrich their SML.	2020	Colombia	Providing Undergraduates with Opportunities to Explicitly Reflect on How News Articles Promote the Public (Mis)understanding of Science
Toth, E. E., & Graham, M.	14 pre-service elementary teacher	Qualitative Using an	The findings indicate that the TLS can be an	2016	USA	Preparing Scientifically Literate

S. [10]	candidates	exploratory, descriptive design	excellent starting point for showing undergraduates some of the various ways in which news items foster public (mis)understanding of science and, hence, enrich their SML.			Citizens: Pre-Service Teacher Candidates' Use of Normative and Logical Thinking for Critically Examining News-Media.
Kim, H. S., Kim, S., Na, W., & Lee, W. J[11]	23,000 elementary and middle school students participated	developing web-based coding	Information scientific literacy has shifted to computer meta-thinking evaluation. Nations must standardize national measurement tools to correlate ICT to computational thinking. Dichotomized difference abilities to be to align students' computational thinking abilities.	2021		Extending Computational Thinking into Information and Communication Technology Literacy Measurement: Gender and Grade Issues
Garcia, A. L., Farran, J. D. A. P., i Farreny, E. T., & Gorrindo, F. R[12]	n -1500 professional engineering graduates in the ICT sector	Quantitative survey	Spanish university does not focus that graduates acquire these qualities,	2019	Spain	ICT skills comparison: the before and the after of introduction of the EHEA in Spain.
Foong, L. M.[13]	1220 respondents from the age of 16 to 40 were involved in this study.	Quantitative survey	The results also show that there is no significant difference in all digital skills from gender and location of residence aspect.	2018	Malaysia	Digital Skills Measurement: A Study on the Malaysian Youth
Tubaishat, A., & Habiballah, L[14]	A total of 541 students	A descriptive cross-sectional survey in two universities in Jordan,	Students have a moderate self-perceived level of eHealth literacy They are aware of the available online health resources and know-how to search, locate, and use these resources. Yet, they lack the skills to evaluate them and cannot differentiate between high and low-quality resources.	2016	Jordan	eHealth literacy among undergraduate nursing students
Gqokonqana, O., Olarewaju, O. M., & Cloete, M. B. (2022).	119 of students studying Cost Accounting 2	Quantitative	blended learning is excellent for studying Cost Accounting 2	2022	South Africa	Blended learning for teaching Accounting students

The study findings reveal concepts employed were different in terms of methodology, where the quantitative method was more than the qualitative method. Out of 16 articles included in Table 2, only 2 employed case studies as well as an online survey, while one differs mixed method. The articles in Table 2 were congruent in terms of recruited population in higher education than basic and secondary education, which is the main concern of information scientific literacy in Africa. In addition, our review identifies information scientific literacy

setting is centralized in Europe and the USA. Other countries include India, Central Anatolia, Columbia, Malaysia, and Jordan in table 2. Significantly, the scientific literacy network gap is still very wide in the African continent, only one out of the fifteen articles featured a South African scholar. Desirably, science educational information scientific literacy lacks skill human resources at the basic level and scholarly intervention. As such cannot contribute significantly to boosting the understanding of students, and to reforming science in Africa.

A. Processes involved in different approaches and implementations of scientific literacy curriculum knowledge domain

Table 3: A tabulated analysis on curriculum review

S/N	Skills	Improvement	Conclusion	Type	Country	Subject	How curriculum was implemented
1. **Cartwright, N.W et al. 2020**	Science knowledge literacy	• knowledge application • knowledge translation and communication	Concluded that students the perception of students towards their SL capabilities does not align with principal practical capabilities.	Experimental research	Canada	Biology	
2. Auerbach, A.J & Schussler, E.E. (2017)	Process skills added to lecture and lab work	higher gain of student scientific literacy	Concluded that scientific literacy retention literacy did not differ between the cohorts.	Experimental research	USA	Biology	Active-learning techniques were used to pair with student collaboration
3. Stuart T. Fraser (2020)	Students develop digital literacy skills	There is need to improve the quality of scientific information on Wikipedia	There is also need to help academicians with the introduction of Wikipedia editing article tools into existing curricula efficiently and effectively.	Document analysis	Sydney Australia	Medical Science	
4. Gormally,C. et al. 2012	Scientific literacy inquiry skill	Students' proficiency based on inquiry method that leads to the ability to analyze, organize and interpret the data and scientific information	impacts of curricular reform on students' scientific literacy	Mixed method	USA	Biology	There is need to develop and validate the testing of the Test of Scientific Literacy Skills (TOSLS)
5. Čipková, E.	Test of Scientific	level of the	There is the need to improve	Survey design	Bratislava	Geography	item analysis

et al. 2017	Literacy Skills (TOSLS).	acquired scientific literacy skill	graph, and various statistical data competencies				
6. Brady, A.J. 2017	scientific practices	scientific culture	It is vital to improve the proficiency in utilizing tools that support scientific inquiry and interpret information generated from such tools (symbols and meanings)	Document analysis	USA	Culture	
7. Koffman, B.J et al. 2017	Strategy for using scientific argumentation	Promotion of knowledge, critical thinking, and the scientific method understanding needs to be promoted.	The writing and learining of students has a significant relationship with an inquiry-based approach.	Experimental research	University of Maine, USA	early undergraduate laboratory geoscience course	
8. Ahmed, Mohammad Waseem, et al. 2020	Conceptual understanding of scientific concepts	increasing scientific curiosity and literacy	showed a significant gain in students' confidence in their conceptual understanding as a result of the engaging demonstration	Experimental research	USA	non-science majors	activities that promoted skills critical in STEM fields
9. Resendes, K. K. (2015)	Development of student skills in information literacy and writing	provided for improving the module to enhance the link between teaching students' skills in experimental design and execution	the module is used in enhancing teachers teaching skills.	Experimental research	USA	Biology	three-week laboratory module
10. Gottesman, A. J., & Hoskins, S. G. (2013).	Scientific Thinking skill	perceptions and understanding of science improved and epistemological beliefs about science gained	Students tends to gain from the ability to think scientifically.	Experimental research	New York	Biology	Introduce as a new one-semester for new student
11. Novick, L. R., & Catley, K.	Science thinking	tree-thinking abilities due	Appreciation of interconnectedne	Experimental research	Carolina	Biology	multi-week tree; thinking

M. (2018)	literacy	to their instruction	ss of biology concepts by the students.				curriculum
12.Lee, Y. H. (2018)	Science critical thinking literacy	Self-directed learning is enhanced through a flipped learning conditions	the use of Collaborative Questioning, Reading, Answering, and Checking (C-QRAC)	Experimental research	Taiwan	educational psychology	use of the C-QRAC collaboration script to facilitate students' critical thinking
13.Krell, et. 2015	Nature of Science	explicit approaches are effective when fostering an informed understanding of NOS	explicit approaches are effective when fostering an informed understanding of NOS	Experimental research	Germany	Pre-service science teacher	
14.Impey et al., 2017	Tracking students (non-science majors) beliefs and attitudes about science and technology	Stable growth in the opinions and beliefs of students on science the basic scientific knowledge of undergraduate non-science majors is stubbornly stable over 27 years	student knowledge shows almost no change over the past 27 years. College students have a positive attitude towards science and technology that is constant over time. expect changes on little issues about societal importance	Survey and document analysis	Arizona USA	undergraduate non-science students	non-science major students the subject requirement to take one science major course.
15.Schalk, 2012	Improving science literacy through increased scientific knowledge	Matured beliefs about the NOS (Nature of Science) and reasoning are being improved.	The SSI-based intervention provides learners with opportunities for scientific literacy	qualitative research (NVivo 6 coding)	USA	microbiology course for undergraduates	SSI-based curriculum and the teaching methods enhanced students' understands social issues which affects lives.
16.Parthasarathy, 2015	Scientific knowledge literacy	To enable students to learn learn how physical principles guide and constrain life. To improve students understanding of scientific data	The Biophysics course improved students' scientific knowledge thereby increasing their literacy and impacting their life.	Experimental research	Eugene OR USA	General education undergraduate course	Using biophysics as a vehicle to address scientific literacy. Use and implementation of evidence-based pedagogical methods in all

							education courses
17.(Amirshokoohi, 2016)	Environmental literacy	STS issue-oriented method course improved preservice teacher view of STS issues and instructions	STS issue-positively influenced pre-service teachers' level and their perceptions toward STS issues and instruction to issues to elementary students	mixed methodology design (quantitative and qualitative)	USA	Preservice teacher elementary science course	STS issue-oriented curriculum was designed with methods and tools for pre-service teachers to improve their knowledge, and attitudes towards STS issues
18.Weber, 2016	Scientific literacy	The use of multiscalar topics increases students' understanding of the cell's position within an ecosystem and how cellular biology interfaces with other disciplines.	Multiscalar topics in undergraduate cellular biology courses is associated with biological literacy in students	Experimental research	Idaho State University	cellular biology	The use of multiscalar topics, in diverse disciplines like sociology and physics. Is s facets of a single system problem, emphasizing the need for the core concept in biology
19.Competente, 2019	Environmental literacy	The inclusion of climate change education of PSTs helps in improving Improve Awareness of PSTs in climate change	There is a need to include climate change education in the student and faculty development programs.	Mixed methodology design (quantitative and qualitative)	University of Nueva Caceres (Philippine	Environmental education	Improvement of climate change can beachieved through providing stuudetswith activities about climate awareness
20.Yildiz, 2018	Science" and "science history literacy	Improve the beliefs of pre-teacher ab out science and history	The low female scientists is as a result of socio-cultural factors, however teachers perceived that courses rich with science history can help adopt teachers centered approach that	Qualitative research	Turkey	Prospective science and science history teacher	The addition of science and science history to curricula

			involves teachers explaining intension of various scientist.				

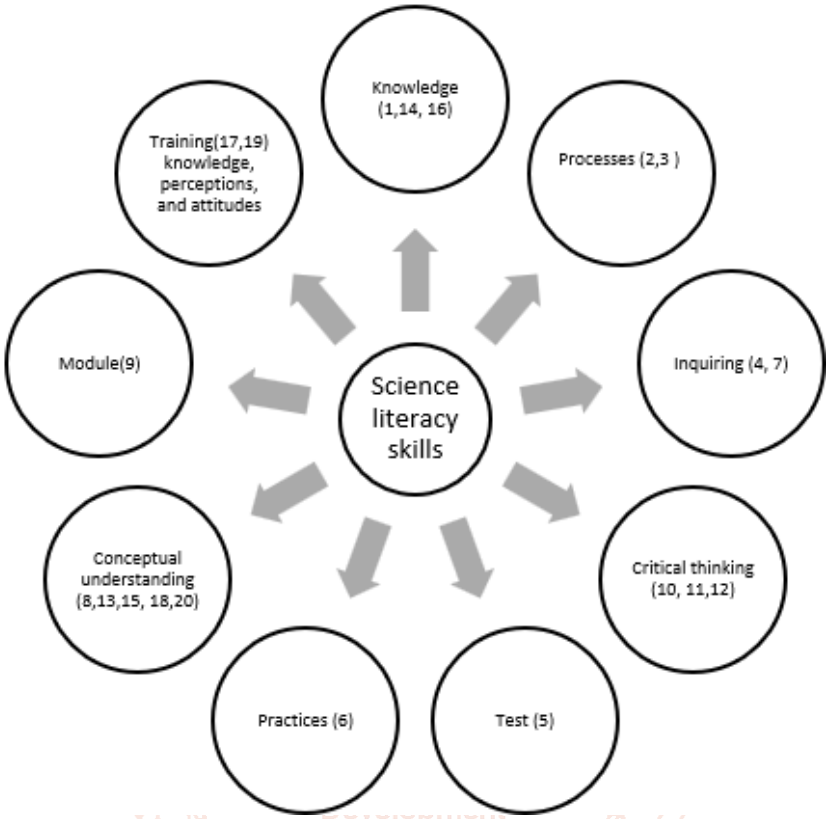


Fig. 2: illustrating the science literacy skills approaches

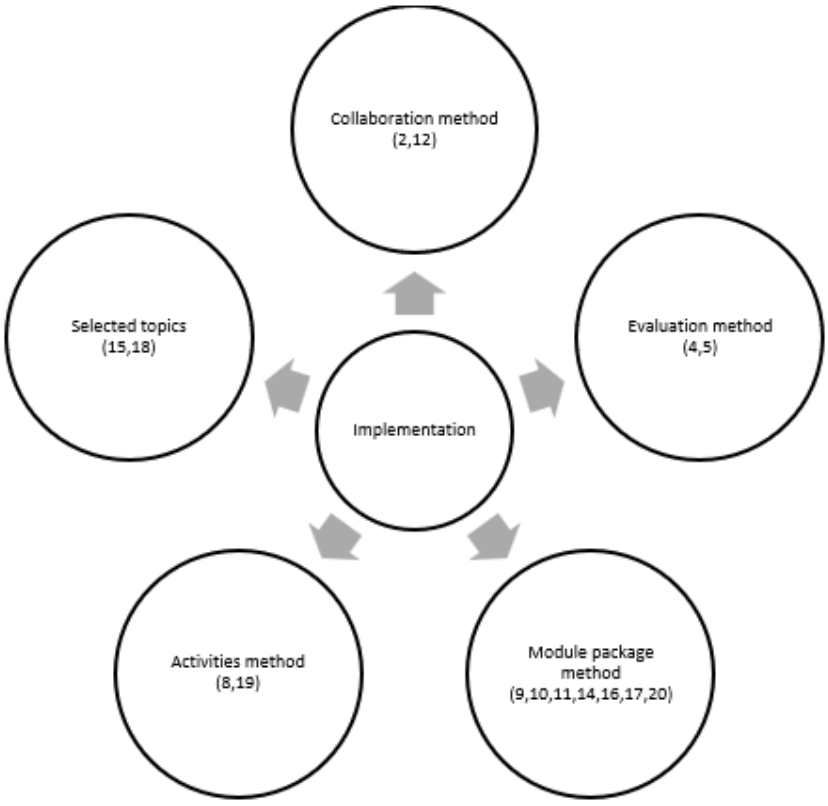


Fig. 3: illustrating the implementation of the science literacy skills approaches

In this study, our team analyses the 20 articles that meet up to the criteria to address research question three. 11 out of the articles are experimental research designs and they are all carried out mostly from countries with a higher socio-economic background such as USA and Canada. The kind of skills that resulted in different approaches by various countries are categorized and shown in fig. 2. It shows that most of the approaches on scientific literacy curriculum knowledge domain employed by the various authors were based on conceptual understanding, knowledge, and critical thinking.

It was shown in table 3 that not all the authors accessed the implementation processes, and according to the categorized implementations strategies, as shown in fig.3 of scientific literacy curriculum knowledge domain reflecting on other continents, was majorly based on five processes "Collaboration; Evaluation; Activities; Module packages and selected topic methods". The intervention of preparation of module packages as extra-curricular for the students. Table 3 further shows the relevance of the research design that can be adopted for the process of the implementation, as revealed by the studies that preparation of module packages is effective and this was done in two ways either by adding the module packages to the semester curricular or creating a special time for the experiment.

In the process of carrying out the collaboration method, the authors revealed a precise important strategy using active-learning techniques either to brace the students or the use of Collaborative Questioning, Reading, Answering, and Checking (C-QRAC) coaction script facilitate students' cognitive thinking and discover their self-directed learning in flipped learning.

The activities method implementation is similar to that of collaboration, which encourages students learning engagement that both led to the acquisition of scientific literacy skills and also in understanding the conceptual scientific concepts for non-science majors, activities method can help in stirring up scientific curiosity and literacy. Secondly, as revealed by the study the activities method can help students to increase their awareness of their environment, which is one component of any curriculum.

Another method that was shown in fig.3, selecting a topic which is so relevant to conceptual understanding development to overcome cognitive barriers and offers learners with practical opportunities to foster their scientific pathways. Lastly, the evaluation method is used to improve Students' proficiency and competencies.

Discussion

Generally, the scientific literacy program seeks to address the principle of reductionism and holistic research curriculum, information, and gender equity domains accomplished in Africa? The study is grounded in policy direction to encapsulate new educational research for developing countries, especially in Africa. The "Eros of Education" envisages new thinking, feeling and acting integrated with high schools ("knowledge, affection, and power") for Africa (Hewison & Kuras, 2005). Throughout these reviews, only one longitudinal conference manuscript focused on digital communication terrain in Africa. Moreover, the need for increased visibility on African research output, fostering collaborative exchange information dive on scientific literacy across the continent is minimal. Boosting scientific communication and open access requires stakeholder-government collaboration, that will rope in the academia with resources to adapt and transfer knowledge into the African continent. The information and communication section envisages that all public-resourced scientific knowledge must belong to all. Government policies should keep in touch with researchers, publishing preprints, innovative scientific groups, to be well informed about scientific development in the 21st Century. Therefore, information and communication flow is networking across all knowledge economies of institutions, and researchers, to implement novelty in scientific literacy in Africa.

In answering the research question, how scientific literacy in all domains is improved in African? We suggest that, is not enough to rely on institutions and scholars. The African continent needs innovative science parks purposely for collaborative scientific research Information. Basic information scientific literacy groups from high school students are the way forward. Policy development of students computational thinking and reasoning from basic, secondary through higher education. Preparing learner's scientific literacy is at the basic educational level, to sharpen their skills and logical reason with a good learning environment. One key factor studied under the information scientific literacy education index exacerbated in African, is the youth using information communication studies to widen knowledge rather than social media entertainment and socialization. African states have suffered from utilizing ICT to benefit youth education, fueling and sparking youth internet money-making adventure. This study observed flipping classroom evaluation with teacher-learning information sources online to deepen scientific understanding and public misconception of internet learning mechanisms.

Therefore, online information is means to collaborative scientific literacy, on the world stage, which is 'key' growing curriculum development. It is an indispensable source that cannot be ignored in this stage of information scientific literacy.

Strategies and processes of implementation of scientific literacy curriculum knowledge domain Scientific literacy as a curriculum objective to build skills

Recent discussions of the school science curriculum have focused on achieving "scientific literacy" as a curriculum goal. However, there is no clear agreement among authors about what this concept means. It signifies a shift in importance, from science courses that are designed to help develop the kind of knowledge future scientists need, in the direction of courses that seek to develop the kind of scientific knowledge and understanding that is essential to all citizens.

From the papers analyzed, Parthasarathy (2015) asserts that one way of improving science literacy is through general education courses in other words courses prepared for students not majoring in science technology, and engineering fields, to give more students a formal experience of uncovering the scientific knowledge. In the same view, in an attempt to improve science literacy in the United States, a new General Education curriculum was introduced (article 18) see table 3 for review. Non-science majors may take two or three science courses as part of a Liberal Arts "breadth" requirement. Efforts to "increase" scientific literacy and skills, suggested that it may bring some distinctive ideas into discussions about the relevant skills for the school science curriculum. From fig3 we identified 9 scientific literacy skills to include "*knowledge, critical thinking, inquiry* ….". Literacy in science is grounded in a wide variety of skills that enables learners to read and access a large volume of knowledge and science content. This backs up a powerful argument identified by (article 2) in table 3, that scientific literacy is embedded in the ability of students to understand and analyze scientific literature, interpret and apply them to new situations. As science cannot be separated from science text and literature.

Therefore, the ability to read text and literature is the key to understanding science. 'literacy' is a thereby fundamental component of science literacy. The process skills of science involve students hypothesizing and carrying out experiments. With active learning technique implementation, text design with explicit diagrams including hypotheses and results. Students gain high science literacy scores, develop an ability to identify valid scientific arguments, pretend knowledge and apply this learned knowledge in real-world scenarios. The process skills as identified by author 4 in table 3 include argumentation and reasoning, students analyzing data and evidence in items, and weighing the facts about evidence. Critical thinking skills as a goal of the science curriculum involve the solution of problems and the making of decisions because critical thinking occurs in a context that is problematic or that involves interactions where rational decisions need to be made about what to do or believe. Following the idea of the practice of making informed judgment is the inquiry-driven enterprise that is mainly aimed primarily to understand the natural world, how it works, and the physical evidence that informs that understanding and the causal models that explain it.

Ways to improve scientific literacy in Africa

As noted by the authors, the study found out the various approaches and implementations of scientific literacy curriculum knowledge domain reflecting on other continents with better or higher socio-economic background approaches. We suggested that Africa as a continent can learn and implement some of these approaches that can solve some of the problem scientific literacy problems noted by (Martinez. et al-2015; Juan 2017; Margaret,2021; Ojimba,2013).

In addition, scientific practices as skills illustrate the place of culture in any curriculum, author 6 in table 3 explained the importance of this to the students, it helps to gain expertise in utilizing tools that upkeep scientific inquiry and interpret information bred from such tools (symbols and meanings). Africa as a continent need to identify our symbol process as a practice and interpret the meaning to scientific inquiring that can lead to proficiency in utilizing tools. As we have seen in other continents that utilizing their scientific tool. Therefore, future work could carry out experimental research as this study has revealed in table 3 as the best way to implement the curriculum concerning various cultures in the African context.

Conclusion

Based on the information drawn from the papers reviewed, we can conclude that other parts of the world such as Europe, America, Asia have expressed the nnature of male and female participation in science-related discipline otherwise known as science literacy. The lack of research into this area of study has become a source of concern for Africa as a continent. Research into science literacy especially as it's related to gender will not only help in creating awareness on the need for a female to be duly incorporated into science education but will also help to promote economic development in Africa.

From this systematic review, we concluded that although research has been published in a different field on scientific literacy, one of the general problems is the lack of implementations in different African Countries. The study anticipates initiative frontiers collaboration among AU countries and European countries. This will facilitate academic exchanges among researchers and the mobility of students. We recommend that there is a need to review the curriculum, raising awareness of science in our lives, society, future require an urgent policy to improve the quality of education, providing supporting environment for science and technology and innovation (STI) which is also the key vision of OAAD. African's access to information technology is no longer a mere lip service, there is the need to speed up and implement research of scientific information, technologies, and products. The agenda 2063 African Outer Space Strategy by AU must integrate and prioritize information of science literacy at higher education levels. This will strengthen and bolster science knowledge, scientific curriculum reforms, and socio-economic development.

The current research is an eye-opener to what other continents with higher socio-economic background has done to improve their scientific knowledge literacy and also provided a framework for future study in the African context. However, the study cannot be generalized as some countries with higher socioeconomic backgrounds were not represented, as the study was only based on English articles. Nevertheless, our study was able to highlight the required scientific knowledge literacy skills and their implementations.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

The authors have no funding to report

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