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Research Article

Artificial intelligence is important! A mini systematic literature review of bioethics in science learning

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Abstract: The focus and concern of researchers on the theme of bioethics and its relationship with science learning is highly expected, as evidenced by publications in reputable journals. The purpose of this systematic literature review (SLR) was to review and compare investigations of researches on article published by scopus indexed journals. We used the phrase "bioethics+learning+science" in the search menu of the scopus database, and found 138 articles. Furthermore, 15 articles met the criteria to be analyzed. The inclusion and exclusion model used is PRISMA. The publication of "bioethics" in the scopus database is likely to increase in 2012. Although in 2013-2022 there were fluctuations. This theme can be approached through qualitative or quantitative and even mix-method. Almost all types of populations/samples have been used as subjects, showing that this theme is broad in dimension and involves all parties. Leonora Kaldaras is the most dominant researcher in reference. Bioethics specs are related to artificial intelligence. The keyword artificial intelligence is related to student, teaching, engineering education, computer science education, education computing, and education. Interesting things on the theme of artificial intelligence related to learning systems and computer aided instruction. The theme of "bioethics" is the focus of researchers from all continents and is generally written in groups. There are four institutions in the world that fund research and publications on bioethics, while the others are not mentioned Most publications have fulfilled one of the ethics in publication, which is to clearly mention the name of the institution / institution that funds their research and publication. We formulate and discuss all aspects of the trend. The alignment of researchers continues to increase regarding "bioethics", which can be seen based on distribution year, research types / methods, instruments, aspects of study, author, keywords, author's internationality, and collaboration. This information or findings gives us new insights to think clearly about research and the relationship between bioethics, science learning and artificial intelligence.

Keywords: artificial intelligence; bioethics; science; systematic literature review

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1. Introduction

Bioethics is a scientific discipline that uses moral theory to analyze the ethical aspects of action in health care, research, and biotechnology (Nagornykh, 2022). It includes different understandings of one's concepts, including naturalistic philosophy, communitarianism, and humanistic positions (Stoff, 2021). The personalistic approach suggests that the human being is an inseparable entity that unites the subjective and objective aspects of existence (Hołub, 2020). Bioetika didasarkan pada persepsi individu sebagai kepribadian dan makhluk sosial yang terintegrasi, dengan norma-norma moral yang berakar pada konsep martabat manusia (Steger, 2015). Bioethics is based on the perception of individuals as integrated personalities and social beings, with moral norms rooted in the concept of human dignity (Steger, 2015). The acceptance of bioethics in different cultural and historical contexts, such as China and the Soviet Union, has been influenced by a variety of factors, including political, ideological, and religious considerations.

Modern biology has developed in close relationship with bioethics. Bioethics serves as a bridge between scientific and non-scientific nature, overcoming ethical conflicts that arise in the practice of medicine and life sciences (Fangerau & Badura-Lotter, 2019). The

development of biomedicine, a branch of biology, has been intertwined with the evolution of ethical theory and applied ethical arguments (Meshcheryakova, 2018). Bioethics not only regulates biomedical research but also stimulates scientific discoveries, playing an important role in the development of biotechnology (Antara & Sumarniasih, 2023). Discourse on the pros and cons of biotechnology products between religious groups, ethicists, NGOs, and biotechnologists continues, highlighting the importance of sustainable bioethics in the field (Griffiths, 2021). Biology itself contributes to the structure of bioethical sense-making, since different interpretations of the ontology of life shape moral judgments in bioethics (Ivanov, 2022).

In connection with that, in recent years, the world has been enlivened by artificial intelligence (AI). The development of AI has had a significant positive impact in the fields of education and biology. In education, AI has enabled the development of adaptive learning systems that can tailor teaching materials and methods according to the individual needs of students. It provides a more personalized and effective learning experience (Chen et al., 2020; Grassini, 2023; Griffiths, 2021; Kamalov et al., 2023; Tuomi, 2018; W. Xu & Ouyang, 2022). On the other hand, in biology, AI is used to analyze genomic data, identify complex patterns in DNA sequences, and understand the genetic basis of disease. The technology also supports research in molecular modeling, drug manufacturing, and drug interaction prediction (Bhardwaj et al., 2022; Dias & Torkamani, 2019; Han et al., 2023; Long et al., 2023; Sahu et al., 2022; Vora et al., 2023).

Thus, the development of AI has changed paradigms in education and biology, bringing profound innovations in science/biology learning and scientific research in biology (Kamalov et al., 2023; Kraus et al., 2021; Subbiah, 2023; Xu et al., 2021). The question is, is the research that has been published in reputable international journals, everything is interrelated? This is what is interesting to study.

Therefore, based on the results of a search in the Scopus database conducted in February 2024, it was found that there were 206 documents found in searches with the keywords "Artificial intelligence" + "systematic literature review" in the Scopus database. If we add the keyword "learning", there are only five systematic literature review articles (Bhatt & Muduli, 2023; Manhiça et al., 2022; Rizvi et al., 2023; Smit & Smuts, 2023; Zhan et al., 2022). In the context of AI, ethics and learning, only three SLR articles are found (Khan et al., 2022; Mouta et al., 2023; Vargas-Murillo et al., 2023). No SLR has been found that raises the theme of bioethics. `

Therefore, the purpose of this SLR is to review and compare investigatively various studies on articles published by journals that have been indexed in Scopus related to the theme of bioethics and science learning and their possible connection with artificial intelligence. This SLR is expected to contribute to the development of bioethics, science learning and artificial intelligence studies that can be a reference for researchers and readers on this topic. We focus on the publication of original articles in relation to the theme, bioethics and artificial intelligence, something that no other researcher has done to provide a research baseline. The review of the scope of information we use only includes research/original articles, thus providing an overview of the trend of focus and alignment of researchers related to this theme.

2. Materials and Methods

2.1 Research framework

This study is a Systematic Literature Review (SLR). SLR helps synthesize current circumstances, identify research gaps, and understand limitations in specific research topics (Cranston et al., 2023; Gengler & Acevedo, 2023). It is invaluable to graduate students because it enhances their professional development by enhancing research skills, such as critical thinking, data analysis, and paper writing. SLR also allows researchers to conduct in-depth literature reviews, gain a better understanding of their research field,

and recognize research problems (Faustino et al., 2022; Iwazaki et al., 2022). SLR has been widely used in the field of environmental literacy and learning (Husamah et al., 2022a, 2022c, 2022b, 2023; Nurwidodo et al., 2023; Rahardjanto & Husamah, 2022), so it can also be used in bioethics themes.

2.2 Research Question (RQ)

The determination of research questions is used to define the scope to develop a clear focus for the study. This research question is made based on the needs of the chosen topic, namely how is the trend of publication of the theme "bioethics and science learning" in journals indexed by Scopus?

2.3 Search article and inclusion criteria

We use the words "bioethics+learning+science" in the search menu in the Scopus database. The data obtained is stored in *CSV* and *RIS* formats which are then synchronized into the Reference Manager (Mendeley). VOS-Viewer software is used to visualize data so that information is presented more communicative, interesting, and clearer. The search history in Scopus is as follows: "TITLE-ABS-KEY (bioethics + learning + science)"AND (LIMIT-TO (DOCTYPE, "ar")) AND (LIMIT-TO (LANGUAGE, "English")) AND (LIMIT-TO (OA, "all")). With these words and search patterns we managed to find 138 articles. We use the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) model for inclusion and exclusion. The following important points are the basis for the inclusion criteria that we use in this SLR, namely (1) publications including the type of research / original article; (2) the article is published in English; (3) articles are open access only. The order of inclusion and exclusion that we do as presented in Figure 1.

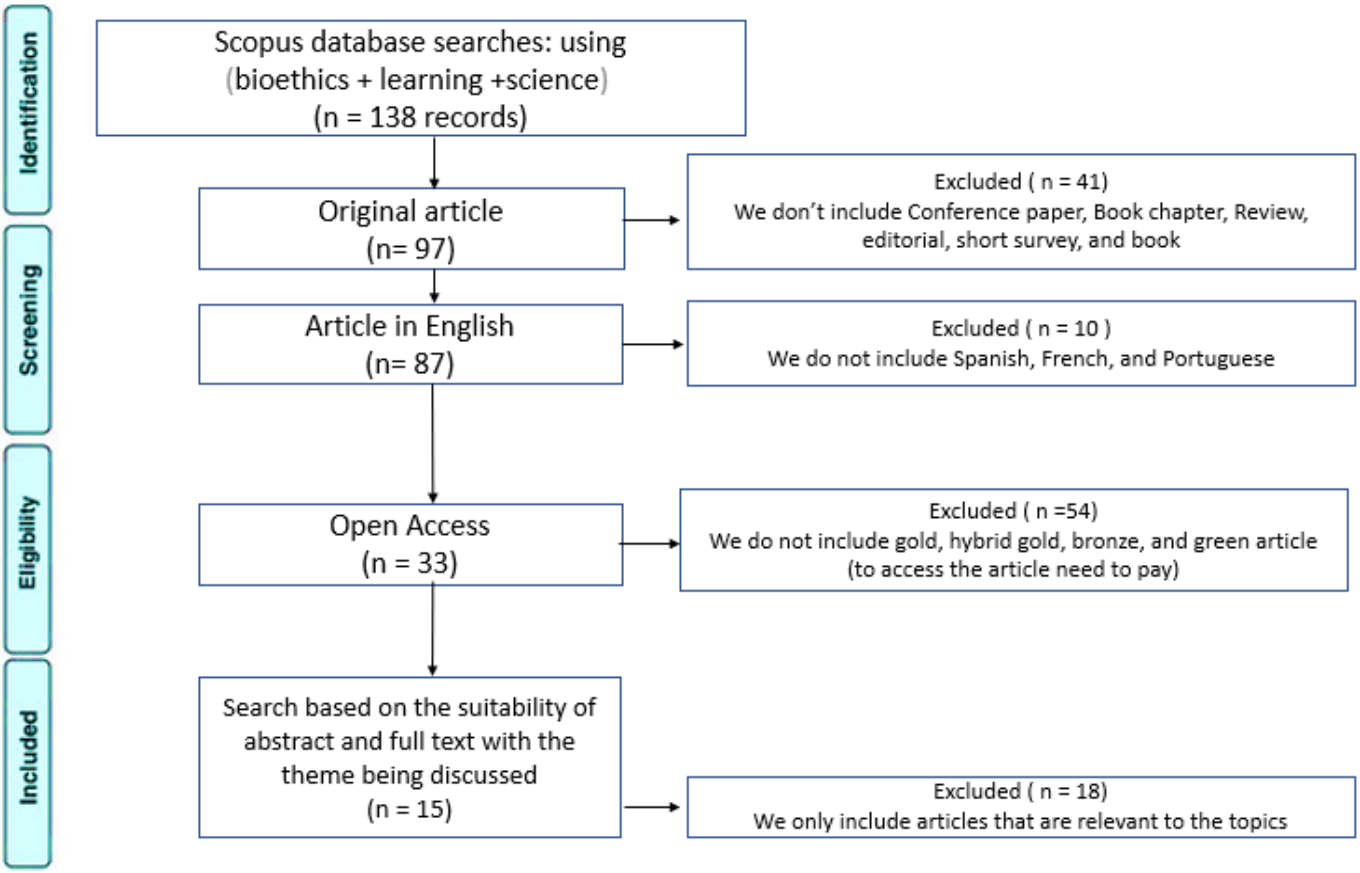

Figure 1. Systematic review flow diagram. Caption: the PRISMA flow diagram for the systematic literature review detailing the database searches, the number of abstracts scereened and the full texts retrieved.

Figure 1 it can be seen that our initial search found as many as 138 articles. We used research/original articles and with that criteria there were 97 eligible articles. There were 41 articles excluded. Then we use the criteria of articles that use English and with that criterion there are 87 articles, which means there are 10 articles excluded. Next we use the open access article criteria. There were 33 articles that met the criteria, which means that there were 54 articles excluded. We decline inappropriate subject areas, such as gold, hybrid gold, bronze, and green article. In the last phase, we review existing articles, make sure they match the themes discussed, make sure the fulltext is accessible, and the articles are published in English. Based on this, we get 15 articles that match or meet the criteria which means 18 articles are excluded.

3. Results

3.1 Distribution year

Figure 2 shows the number of articles published annually from 2010 to 2022. Based on Figure 2, it can be seen that the highest number of publications on the theme of bioethics was in 2012, namely 3 articles. Where in 2012 discussed issues in biomedicine related to genetics. But in the year the trend of articles on bioethics decreased. And then in 2017, 2018, and 2021 experienced an increase from the previous year with trends regarding health medical bioethics. But in 2022 there is no increase. And in 2023 there are still no published articles.

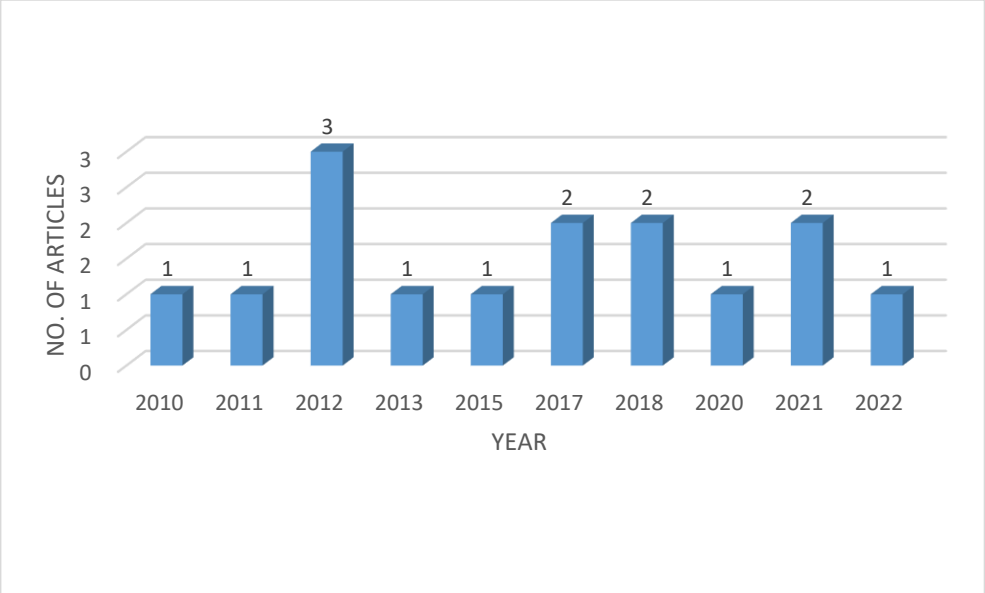

Figure 2. Distribution year of article

3.2 Research types/methods

The trend of types pf research related to "bioethics" themes is presented in Table 1. Bioethics research is predominantly carried out with a qualitative approach (10 articles). Quantitative research can also be used a number (4 articles). This shows that bioethics issues can be approached through quantitative and qualitative. Therefore, some researchers are also interested in using the mix-method in 1 article.

Table 1. Types of research on bioethics themes

No	Type of Research	Amount	References
1	Quantitative	10	(Chastonay et al., 2012); (Chowning et al., 2012); (Edwards et al., 2022); (Halkoaho et al., 2013); (Hernando et al., 2018); (Jones et al., 2010); (Moorthy et al., 2011); (Moorthy et al., 2012); (Okoye et al., 2017); (Thant & Nussbaum, 2020)
2	Qualitative	4	(Cambra-Badii et al., 2021); (Dixit & Sadanandam, 2021); (Eriksen, 2015); (Goodman, 2020)
3	Mix-method	1	(Allen et al., 2017)

3.3 Author and keywords

Based on Figure 3 it can be seen that the most references are L. Kaldaras; K.C Haudek, J.W Kim, B. Bredeweg; M. Kragten, X. Zhai; P. He; J. Krajcik P. Wulff; L. Mientus; ANowak, R. Bertolini; S.J. Finch; Nehm, M. Henrich; Zimmer-Formela, M. Kubsch; B. Czinczel; Lossje. Figure 3 also shows the VOSViewer output showing the name that connects and associates the author is L. Kaldaras; K.C Haudek, J.W Kim. These names can be said to be interrelated, collaborating or quoting each other, where the most important references are L. Kaldaras; K.C Haudek, J.W Kim.

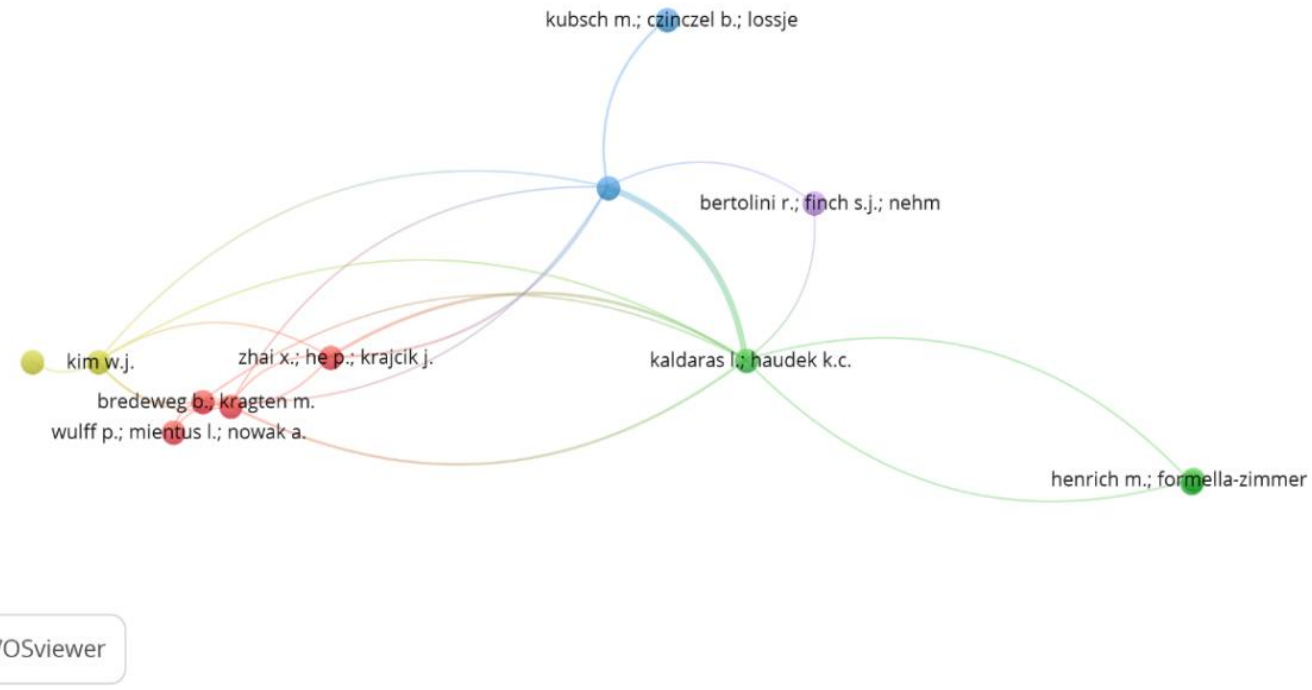

Figure 3. Dominant author and relationship between authors in the theme "bioethics"

Figure 4 shows keywords that are widely used by authors in writing bioethical themes. Based on Figure 4, it can be seen that there is one main keyword that most often appears and is interrelated, namely artificial intelligence. Artificial intelligence keywords are related to student, teaching, science education, and education. The interesting thing is that the theme of artificial intelligence is related to learning systems and computer aided instruction.

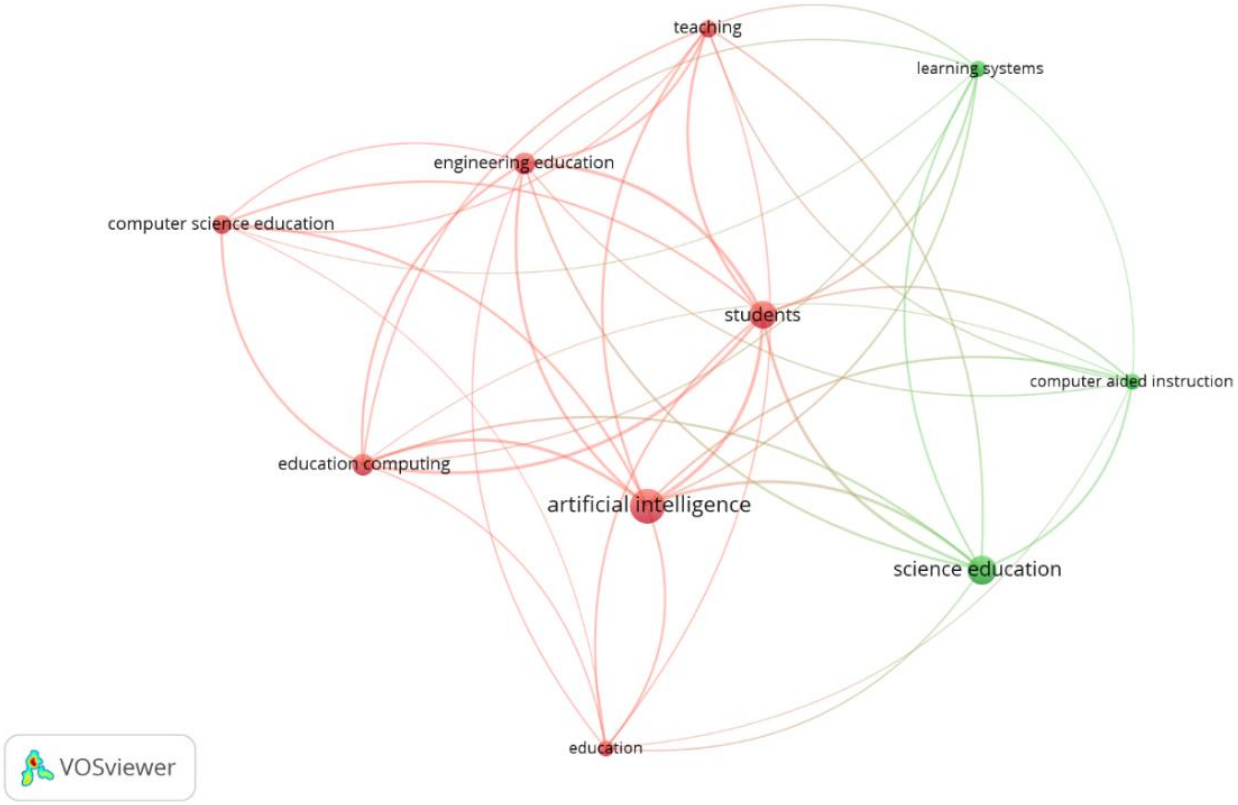

Figure 4. VOS-Viewer display for type of analysis "Co-occurrence → keywords"

3.4 Author's nationality and international collaboration

The trend of author's nationality of research related to "bioethics" themes are presented in Table 2. Based on Table 2, it can be seen that there are 10 countries where the author comes from. The 3 countries with the most publications on bioethics themes are the United States (4 articles), Malaysia (2 articles), and Spain (2 articles). Based on continents, Europe accounts for the most authors who publish on bioethics (47%), followed by America (33%), Asia (13%) and Africa (7%).

Table 2. Author's nationality and continental on bioethics themes

No	Country	Continent	Amount
1	Malaysia	Asia	2
2	Amerika	America	1
3	Switzerland	Europe	1
4	Denmark	Europe	1
5	Nigeria	Africa	1
6	Spanyol	Europe	2
7	Inggris	Europe	1
8	Amerika Serikat	America	4
9	Britania Raya	Europe	1
10	Finlandia	Europe	1

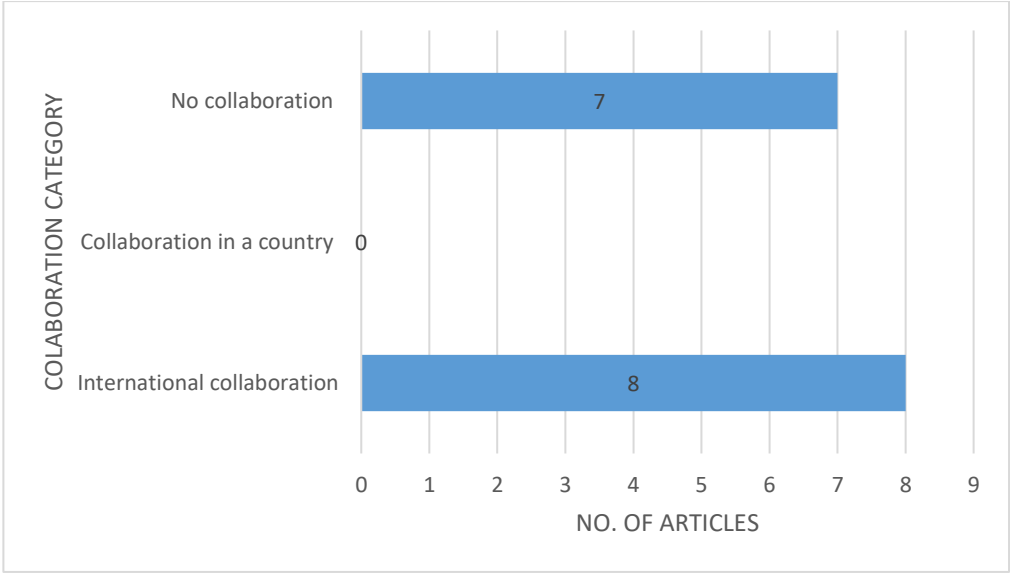

Figure 5. Author collaboration in writing articles

Figure 5 shows collaboration in article publication carried out by authors, both cross-country collaboration, collaboration between universities in one country, and non-collaboration. Meanwhile, Figure 6 is an overview of the distribution of scientist collaboration.

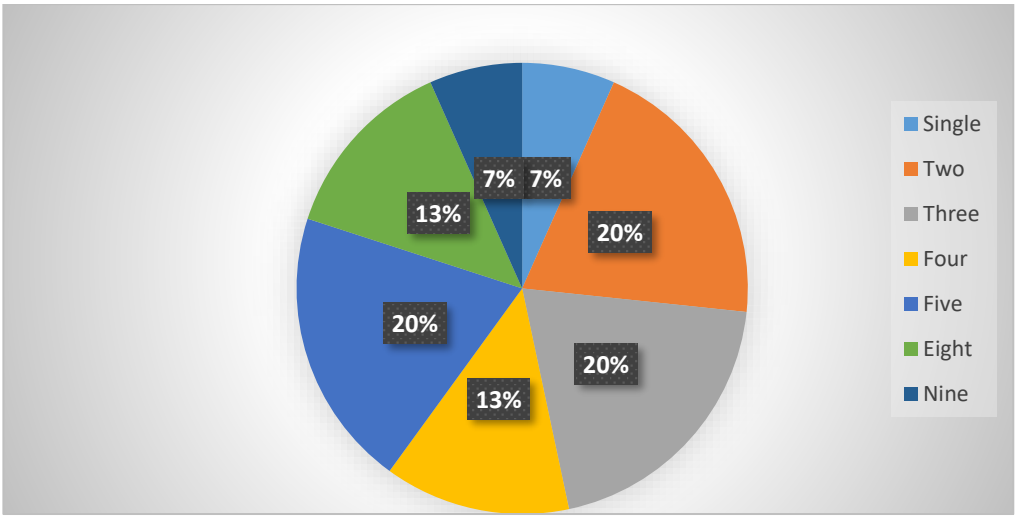

Figure 6. Distribution of scientist collaboration

Based on Figure 6, it can be stated that more articles are published with the status of collaborating in one country as many as 7 articles and in international collaboration as many as 8 articles. So it can be said that most articles are written and published with a collaboration system. If we analyze the 15 articles found (as presented in Figure 6) we will conclude that it is rare to find articles that are written independently (single author). Although only written by authors from one university, it can be seen that they collaborate between fields of science where they join in one research unit at the university. There is only 1 article written independently / single author.

3.5 Funding sponsor

The trend of funding sponsor of research related to "bioethics" themes are presented in Table 3. Based on Table 3 it can be seen that there are 4 institutions or institutions in the world that fund research and publications on bioethics. The National Science Foundation is the institution that provides the most funding. Several other institutions / institutions

fund 1 research / publication each, namely the Agency for Technology and Innovation, National Institute for Health Research Biomedical, and Wellcome Trust India Alliance. We can say that some publications have fulfilled one of the ethics in publication, which is to clearly mention the name of the institution / institution that funds their research and publication. However, there are most publications that do not get research funding.

Table 3. Funding Sponsor bioethics themes

No	Funding Sponsor	Amount
1	National Science Foundation	2
2	Agency for Technology and Inovation	1
3	National Institute for Health Research Biomedical	1
4	Wellcome Trust India Alliance	1

4. Discussion

4.1 Distribution year

There is a downward trend in research on bioethics and science learning every year. However, the number of publications in 2017, 2018 and 2021 has a stable/fixed status, namely 2 articles. Especially in 2022, it is also declining but it can be said. In 2023 it is still not in the Scopus database; it can be possible that the publication process is still running and it is still very likely that the number of bioethics theme publications will increase in 2023 because there are still many articles that have not been included in the Scopus database. However, it can also be said that there is a decrease in interest in bioethical aspects.

The topic of bioethics and science learning may not be of much interest to researchers for several reasons. One possible reason is the lack of emphasis on ethics and bioethics in scientific research and academic training, as observed in studies conducted by Rebello et al (2018) and (Marin et al., 2016). These studies found that there are significant gaps in the production of scientific knowledge related to ethics and bioethics in the field of dentistry, which can lead to a lack of awareness and competence among dental professionals. In addition, Levinson (2004) highlights that addressing ethical issues in the classroom is complex and difficult, and further studies should focus on how non-science practitioners address these issues. Furthermore, Azariah (2009) points out that science and bioethics are incompatible, and there is a need to develop new knowledge systems that integrate bioethical values into science. These factors may contribute to a lack of interest in the topic among researchers.

Bioethics and science learning research in 2012 tends to interest researchers for several reasons. First, there is a growing interest in bioethics education, with numerous conferences and initiatives organized globally to enhance and expand ethics teaching at different educational levels (Chinthapalli, 2013). Second, there is discussion among leading bioethics researchers about the acceptance of cognition-enhancing drugs, which has implications for society and human development (Azariah, 2009). In addition, there is a need to examine the relationship between science and bioethics, since they have different characteristics and values, and explore the possibility of integrating bioethical ideas into science education (Marin et al., 2016). Furthermore, the inclusion of bioethics content in the curriculum for first-year undergraduate and secondary school students is being emphasized, leading to the development of inquiry-based teaching methods and discussion of concrete ethical issues (Sousa, 2017). Lastly, the lack of research and scientific knowledge in the field of ethics and bioethics highlights the need for further investigation and its potential impact on professionals e.g. in the fields of health and medicine (Rebello et al., 2018).

4.2 Research types/methods

Bioethics and science learning research is predominantly carried out with a quantitative approach. There is also qualitative research. One study tried to use a mix-method approach. Bioethics research and science learning can be carried out with quantitative, qualitative, and mixed-method approaches. Various references indicate that a variety of research methods are used in the field of bioethics, including quantitative-descriptive methods (Maldonado et al., 2023) dan pendekatan interdisipliner yang menggabungkan bioetika filosofis normatif dengan metodologi ilmu sosial (Draper & Ives, 2007; Rodríguez, 2012). While some studies may use quantitative methods, such as surveys (Alexander & Wynia, 2007), it is clear that bioethics research encompasses a wide range of approaches and methodologies (Ashcroft, 2003; Dine, 2016; Mertz et al., 2019; Reiter-Theil, 2004; Ribeiro, 2017; Rodríguez, 2012).

4.3 Author and keywords

The author who has been most highlighted in the study of bioethics and science learning and its relationship with artificial intelligence is Leonora Kaldaras. Leonora Kaldaras is one of the researchers in the field of ethics who has become a reference for many other researchers. Leonara Kaldaras is a postdoctoral research fellow. Based on Google Scholar searches, during the period 2013-2023 he has published 96 articles, both in scientific journals and in proceedings. He acts as the first author, as corresponding author or as a member of the author. If you browse the data in the Scopus database, during his career he has published many articles as a first author (Kaldaras et al., 2021: Kaldaras & Haudek, 2022; Kaldaras & Wieman, 2017, 2023b, 2023a).

Based on the data, it can be seen that the keyword Artificial Intelligence (AI) is predominantly used in publications related to bioethics and science learning. AI keywords are related to student, teaching, science education, and education. It can be said that AI is clearly related to science education in which there are students, teaching, and elements of education in general. The application of AI to the world of education will bring new breakthroughs in the application of science learning, based on Science and Technology (IPTEK) in the 21st century.

AI is indeed related to science education, because it can be applied to improve the teaching and learning experience (Sadykova & Levchenko, 2020). This can help personalize the learning process and support teachers in their efforts (Hamal et al., 2022). In addition, AI can be used in educational technologies, such as adaptive learning environments and educational games, to create effective and inclusive tools (Duran et al., 2020). The use of AI in science education can also be seen in the development of chatbots, which aim to increase public understanding and awareness of complex scientific concepts (Florea & Radu, 2019). Furthermore, the COVID-19 pandemic has highlighted the use of AI in distance learning, where educators and learners utilize AI technology for remote pedagogical interaction (Romanov, 2022). Overall, AI has the potential to revolutionize education by improving teaching methods, personalizing learning experiences, and facilitating distance learning.

Bioethics, science learning, and AI are interconnected in several ways. First, AI has had a significant impact on science learning, especially during the COVID-19 pandemic as countries switched to hybrid systems (Hillner, 2023). AI offers new opportunities for education and scientific research, but it also presents challenges that need to be overcome (Riaño-Moreno & Clavijo-Montoya, 2023). Secondly, bioethics, as an emerging field, requires a rigorous approach and dialogue with advances in science and technology, including AI (Díaz, 2022). AI can be applied to decision-making in bioethics, such as the creation of theoretical models based on artificial neural networks (Klugman & Gerke, 2022). Finally, the ethical implications of AI extend to various sectors, including care, health, medicine, and education (Ghosh & Dasgupta, 2022). The importance of ethics in AI is recognized globally, and AI-related technology companies are increasingly recognizing

its significance. Therefore, bioethics, science learning, and AI are interconnected through their impact on education, research, decision-making, and ethical considerations (Boch et al., 2023; Corrêa et al., 2023; Human & Watkins, 2023; Lim et al., 2022; Murphy et al., 2021; Naik et al., 2022).

4.4 Author's nationality and international collaboration

There are 10 countries of origin of authors who publish articles, predominantly from Europe. Bioethics and artificial intelligence issues have gained significant attention from researchers in Europe for several reasons. First, the development and implementation of AI technologies in various fields, including healthcare, has raised ethical concerns regarding accuracy, utility, and oversight (Baihakki & Qutayan, 2023). Second, the integration of ethics into AI is seen as essential to address incidents such as data privacy and security risks, diagnosis of bias, and job loss (Fiorentino, 2022; Klugman & Gerke, 2022). In addition, the use of AI in healthcare has gender-related implications, which further highlights the need for ethical considerations (Pei & Shah, 2022). In addition, the approach of using descriptive ethics rather than prescriptive ethics in AI development has been criticized, as it can lead to Naturalistic Fallacy and ignore strong philosophical theories in bioethics (Dubrovsky et al., 2022). These factors have prompted researchers in Europe to focus on the ethical dimensions of AI and explore how feminist bioethics and social justice principles can contribute to more equitable and respectful care (Baihakki & Qutayan, 2023; Chao, 2019; Huang et al., 2022; Lim et al., 2022; Stahl & Leach, 2022).

Articles about artificial intelligence are written by authors from all continents, showing artificial intelligence to be in the spotlight of the world or become a global issue. Bioethics and artificial intelligence are in the spotlight due to AI's profound impact on various aspects of human life and society. AI is being applied in areas such as autonomous driving, medical care, finance, and internet services, raising ethical concerns regarding privacy, discrimination, unemployment, and security risks (Huang et al., 2022). The development of AI systems has important public policy implications, and is critical to ensuring openness, privacy, and protection of all parties involved. AI, unlike humans, lacks emotion and character, highlighting the need to address AI bioethics and develop new principles to guide its progress (Kurunayakage et al., 2022). The use of AI algorithms can create homogeneous and polarized spaces that reinforce the ethical, ideological, and political narratives of society, as opposed to the prerequisites for democratic deliberation (Riaño-Moreno & Clavijo-Montoya, 2023). In addition, the increasing presence of AI in popular culture and everyday life has sparked discussions about AI rights, ethics, and freedoms (Bylieva, 2022).

4.5 Funding sponsor

There are 4 institutions in the world that fund research and research on artificial intelligence. Research and publication funding is a grant obtained to conduct research and scientific publications in general through a competitive process. Research funding will have an impact on the quality of research carried out so as to make a good output targaet (Azizah, 2021). Most publications have fulfilled one of the ethics in publication, which is to clearly mention the name of the institution / institution that funds their research and publication. The mention of institutions / bodies that provide funding is very important because it shows the honesty and openness of researchers. For, however, funding bodies emerge as clear and influential actors in scientific communication systems, making important decisions about the research supported, and influencing the type of knowledge generated (Caballe & Bardelli, 2022; Guillemin et al., 2018; Hanney et al., 2003; Hosseini et al., 2023; Kennedy et al., 2023; Lemon & Verhoef, 2016; Neema & Chandrashekar, 2021; O'Kane et al., 2023; Resnik, 2006; Rowland et al., 2022; Xu et al., 2020).

5. Conclusions

The alignment of researchers continues to increase regarding "bioethics", which can be seen based on distribution year, research types / methods, instruments, aspects of study, author, keywords, author's internationality, and collaboration. There is a trend of publication of the theme "bioethics" in the scopus database tends to increase in 2012. Although in 2013-2022 there were fluctuations. The theme of "bioethics" can be approached through qualitative or quantitative and even mix-methods. The most referenced name is Leonora Kaldaras. From the keyword aspect, it can be seen that the bioethics aspect is related to artificial intelligence. Artificial intelligence keywords are related to Student, teaching, science education, and education. There are only 10 countries where the author comes from, the 3 most countries in the publication of the theme "bioethics" are the United States, Malaysia, and Spain. If based on continent, then Europe contributes the most authors who publish about "bioethics". Research on "bioethics" is the focus of authors or researchers from all continents and deserves to be a global issue. More articles are published with non-collaboration status. If we analyze the 15 articles found, we will conclude that it is rare to find articles that are written independently (single author). Thus, even though the article is only written by authors from one university, it can be seen that researchers still collaborate between fields of science, so that there is a transfer of knowledge and multidisciplinary problem solving. Thus, it can be said that studies that link artificial intelligence, bioethics, and science education are very important. Future studies can focus on how the forms of implementation are actually in learning or in real educational practice.

6. References

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