Ethics in the Software Development Process: a Tertiary Literature Review

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Abstract. *The study of ethics in computer science has gained significant attention in the past decade, particularly with the emergence of new artificial intelligence (AI) systems. Issues such as Privacy, Fairness, and Transparency are receiving greater attention from researchers and the debate surrounding them is gaining momentum. Despite this attention, practical applications of ethical issues within the software development process are lacking. Our purpose is to present a literature overview, identify gaps and suggest areas for future research. For this, we present a tertiary mapping of the literature summarizing the main advances in dealing with ethics in the software development process. We collected and analyzed 8 secondary studies to gain an understanding of this research domain. Among our conclusions, we found that more research efforts are needed to address ethics beyond the software requirements activities.*

1. Introduction

Recent developments in computer science, encompassing data science and artificial intelligence have reinstated the importance of discussing ethics in software development. Ethical issues such as privacy, transparency, and fairness were brought up considering the pervasiveness and relevance of these modern systems. The fast pace of technological development, though, has not allowed for the proactive formulation of ethical standards. Consequently, this has caused some problems leading to discrimination and bias towards specific groups. Therefore, it is important to discuss the ethics of software development as well as identify and implement strategies to mitigate ethical concerns [Kuleshov et al. 2020, Kamthan and Shahmir 2021, Cerqueira et al. 2021].

Some efforts have been made to address ethical questions in the software development process. Notably, in 1991, a joint effort by the Association for Computing Machinery (ACM) and the Institute of Electrical and Electronics Engineers (IEEE) was made to establish the Code of Ethics for software engineers[1]. The code aims to guide these professionals in dealing with ethical dilemmas, but it is criticized for being too general and sometimes contradicting itself, which could lead engineers to pick values as they suit instead of debating over them [McNamara et al. 2018].

Despite that criticism, it is arguable that developers, engineers, and architects responsible for building software systems do not have the right tools to deal with ethical

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[1]https://www.computer.org/education/code-of-ethics

issues properly [Johnson and Smith 2021]. Also, it seems that there is a lack of reflection from most software builders in thinking critically about the construction of their systems, leading to bias, discrimination, and exclusion of specific groups as well as creating environmental problems instead of helping solve them. Hence, in this study, we highlight the importance of critically dealing with the process of software development.

Within this frame of reference, we conducted a tertiary literature review to find secondary studies that deal with ethics in the process of software development, discuss their findings, and map possible consensus on the theme. We try to answer the following general Research Question (RQ): *What is the extent of secondary literature that addresses the practical implementation of ethical issues in the software development process?* By answering this RQ, we expect to bring clarity to how is the discussion over ethics being held and what strategies are being used to identify and mitigate ethical issues that may arise in the development, deployment, and maintenance of software systems.

From the results of this review, we expect to strongly help identify a body of knowledge to support future research related to ethics in the software development process. Besides that, we expect the review's result provides a valuable resource so that researchers and students interested in exploring this research domain can seek to navigate the complex ethical landscape of software development.

We organize the remainder of this paper as follows. Section 2 describes the background of this study. Section 3 presents the methodology followed by this study. Section 4 details the results obtained. In Section 5 we present a discussion of the results found. Our final considerations are presented in Section 6.

2. Background

Software is not neutral [Gotterbarn 2001, Oriogun et al. 2012, Rosenbaum 2020]. The development and use of software is intrinsically human and it encompasses human values and judgments. According to [Gotterbarn 2001] this myth comes from the fact that software builders don't want to carry the weight of the responsibility of systems if things go wrong. Nevertheless, even though many authors argue in favor of this understanding, this is not a consensus in the literature.

Ethics is a complex set of moral principles defined by each society of how to coexist in a certain place and time [Johnson and Smith 2021]. In this sense, ethics is dependent on the place and time, meaning that it can evolve and change, making it hard to be fully captured and mapped [Shafer-Landau 2012, Aberkane 2018].

Codes of ethics have been proposed to deal with ethical issues in the context of software development. These codes usually present a list of abstract principles that should be followed by the ones committed to it. They are simply descriptive and don't provide means to be enforced or validated [McNamara et al. 2018]. When considering ethics in the development of a software system, we encompass many different aspects that arise depending on numerous circumstances. Considering this, dealing with ethics means dealing with different issues depending on the context. The predominant issues observed currently are related to security, privacy, transparency, and fairness, as described below [Aberkane 2018, Ahmad et al. 2021, Johnson and Smith 2021]:

- **Security** concerns the capability of the system to be able to store data and be pro-

tected in a way that malicious actors won't be able to access it. This is particularly important because of the amount of data that every single user generates. Keeping this data, as well as internal organizational data secure is of utmost importance.

- **Privacy** is related to identity, as well as collecting, storing, and identifying someone based on some data. The issue of security is also relevant because of the amount of data being generated, but this issue is more focused on the necessity of preserving users' anonymity as well as questioning the necessity of collecting this data.
- **Transparency** is currently debated principally in the field of AI. AI algorithms are usually black boxes in which it is not possible to access their decision-making. This led to the emergency of this issue and the discussion of how to make systems more human-friendly. This issue is closely related to the issues of explainability and explicability which are focused on understanding and explaining AI systems.
- **Fairness** addresses the issue of bias. This aspect, defined in the Merriam-Webster dictionary as "fair or impartial treatment" aims at thinking critically about constructing systems that don't discriminate against anyone based on the color of their skin, age, gender, or the many diverse characteristics of each human being.

3. Tertiary Literature Review

Tertiary literature reviews, or simply tertiary studies, are studies that propose to find only secondary studies, i.e., review, mapping studies, and systematic reviews [Kitchenham and Charters 2007]. According to [Kitchenham and Charters 2007], systematic research comprises three phases: planning, conducting, and reporting. Planning involves establishing a protocol outlining the research questions, inclusion and exclusion criteria, study sources, search string, and review procedures. Conducting the review involves selecting primary studies, assessing their quality, extracting and monitoring data, and synthesizing the findings. Finally, reporting involves formatting the report, presenting key results, and disseminating the findings to relevant stakeholders.

For this tertiary study, we used the search string described in Table 1. For the construction of this string we used a suitable search string to retrieve secondary studies as proposed by [Napoleao et al. 2021]. We tested many different versions of this string, including adding more specific terms such as 'software test' and 'software analysis'. However, they did not yield new studies and were therefore excluded from the final version. The final string was applied to prominent databases: Scopus, IEEE Xplore, ACM Digital Library, Science Direct, and SpringerLink, which encompass a significant volume of computer science research. The search encompassed the title, abstract, and keywords of the studies in all databases. This search was conducted on January 3, 2022.

The selection criteria used in this tertiary study are organized into one Inclusion Criterion (IC) and five Exclusion Criteria (EC). The inclusion criterion is: (IC1) The study must present a secondary study about ethical issues in the software development process. The exclusion criteria are: (EC1) The study is just published as an abstract; (EC2) The study is an older version of another study already considered; (EC3) The study is not a secondary study; and (EC4) The full paper is not available.

In the protocol, we outlined a set of specific questions derived from the general RQ, presented in Section 1, which are as follows: "RQ1. What are the main ethical

issues discussed in the literature and to what extent has research covered them?"; "RQ2. What are the key contributions of previous works in the field?"; and "RQ3. What are the primary gaps in the literature concerning ethics in software development?".

Table 1. Search string of the tertiary study

Areas	Keywords
Ethics	"ethics","ethical","moral","ethics-driven","ethics-aware"
Software Engineering	"software engineering", "requirements", "software verification and validation", "software quality"
Secondary Studies	"systematic review", "literature review", "systematic mapping", "mapping study", "systematic map"
Search String: ("ethics" OR "ethical" OR "moral" OR "ethics-driven" OR "ethics-aware") AND ("software engineering" OR "requirements engineering" OR "requirements" OR "software verification and validation" OR "software quality") AND ("systematic review" OR "literature review" OR "systematic mapping" OR "mapping study" OR "systematic map")	

First, we executed the search string on the Scopus database. 26 studies were retrieved. We applied the selection criteria in the title and abstract of the studies, and the number of studies was reduced to 9. After, the selection criteria were applied considering the full text, resulting in 1 study. The same selection process was applied in the IEEE Xplore database and it retrieved 11 studies, but only 2 were considered relevant after applying the selection criteria. When the string was executed in the ACM database, 3 studies were retrieved. Out of these, only 1 study was considered relevant. When executing the search string in the Springer Link database, 2 related studies were retrieved, but since they were not secondary studies, they were discarded. Finally, the search in the Science Direct database did not return any results. Our search in the databases led to the selection of 4 studies.

After carefully reviewing the 4 studies found in the initial search, we conducted a backward snowballing procedure [Kitchenham and Charters 2007] by searching the references of these researches for other potentially relevant studies. This process led to the discovery of 3 new relevant studies. Although these studies do not address ethics in the software development process from the same perspective we were seeking, we found them to be pertinent to our research and will be described here. We also got 1 study from Ad-Hoc research. As a result, we got to 8 studies (4 from databases + 3 from backward snowballing + 1 from ad-hoc research). We did not make a structured quality assessment of the selected studies. The main steps performed are shown in Figure 1.
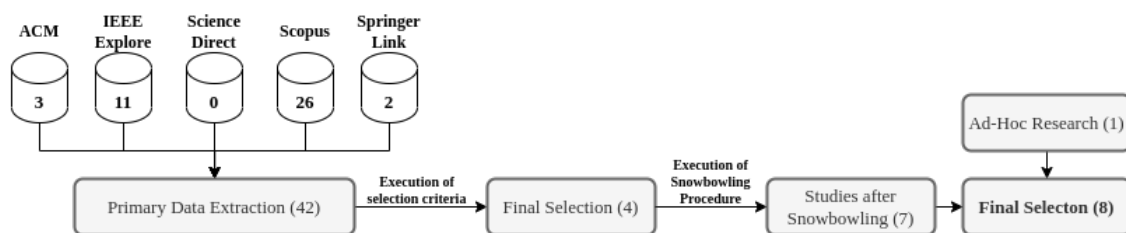
Figure 1. Process of Data Extraction

4. Tertiary Review Results

In Section 4.1, we present a summary of the 7 secondary studies selected and in Section 4.2, we present the main findings from data extraction and synthesis in order to answer the specific RQs.

4.1. Synthesis of selected studies

The study by [Almazroi 2021] is a secondary study that focuses on software usability rather than ethics in the software development process. The author acknowledges the importance of the topic and admits that it was not well considered in his work, suggesting that future research should delve deeper into the theme.

[Ahmad et al. 2021] propose an analysis of the requirements engineering field for artificial intelligence systems. Based on the analysis of 27 studies, they propose a set of recommendations modeled as questions. The main questions that the authors present as relevant are the discussion over the necessity of the use of AI systems in certain contexts and how to adapt current requirements engineering practices for AI systems. While the study provides valuable insights, it primarily focuses on AI-specific requirements engineering rather than software development ethics.

The study by [Johnson and Smith 2021] explores the integration of ethics into the process of building data-driven software. The authors identify open research problems and challenges related to this integration, such as the need for ethical considerations to be present at every step of the process, from data collection to deployment. While the authors' focus is specifically on data-driven software, their approach to considering ethics throughout the development process is relevant to our proposed study.

In their study, [Carvalho et al. 2021] analyzed the Brazilian Symposium on Software Quality[2] and found few articles that mention ethical concerns. This turned out to be their main downfall because the scope of the analysis ended up being too limited. Still, they analyzed the importance of the topic in the symposium and concluded by stating that they observe the potential for new papers to explore ethical issues, as the papers they found were insufficient in depth and number.

[Stahl et al. 2016] conducted a literature survey to identify the main ethical topics within computer science. They found that privacy was the main issue within ethics in computing and that most articles did not provide any explanation of the ethical theory on which their evaluation was based. They also noted that the ethical themes discussed by the papers did not alter significantly over time. Furthermore, the authors mention that less than one-third of the analyzed papers explicitly explained their contribution. A limitation of the study is that it only considered papers published between 2003 and 2012.

[Tsamados et al. 2021] examines algorithms in six different dimensions, namely: Inconclusive evidence leading to unjustified actions, Inscrutable evidence leading to opacity, Misguided evidence leading to unwanted bias, Unfair outcomes leading to discrimination, Transformative effects leading to challenges for autonomy and informational privacy and Traceability leading to moral responsibility. They conduct a systematic literature search, collecting 118 articles from 2016 to 2020. The authors conclude that ethical analysis is important to mitigate risks and improve technology's potential for good.

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[2]http://sbqs.sbc.org.br/

The study by [Morley et al. 2020] proposes an analysis of ethics in AI, searching for ways to close the gap between principles and practice. They argue that short-term incentives are prejudicial for the development of ethical AI, once it requires a more profound observation and analysis of its impact. They advocate for procedural systematization in the machine learning field to facilitate the adoption of ethical practices by developers. Even though they were preoccupied with processes, their focus was restricted to machine learning which is a subdomain of AI.

Finally, in ad-hoc research, we found the study of [Aberkane 2018]. This thesis presents a secondary study in which the author analyzes the gray literature, as well as a systematic literature review of ethics in software engineering. In the analysis, covering the period from 1998 to 2017, the author presents a clear tendency of growing interest in the topic. Also, it is observed that responsibility, code of ethics, and privacy are the main topics discussed within ethics in software engineering.

4.2. Data extraction and RQ responses

An initial analysis was made concerning the protocol of each one of the 7 studies selected. A comparison of those is presented in Table 2. Considering the structure outlined by the protocols of the reviews, it is evident that the Scopus database was predominantly utilized for article extraction, being used by 5 out of 8 studies. Moreover, it is notable that the majority of studies focus on recent years when collecting articles, indicating that research about ethics has gained greater attention in recent years.

Table 2. Protocol Characteristics

Studies	Main Objective	Time Period	Bases
[Almazroi 2021]	Classify studies about software usability	2011-2020	ACM; Google Scholar; IEEE Explore; Science Direct; SpringerLink; Taylor and Francis
[Carvalho et al. 2021]	Review of the SBQS Symposium	2006-2020	SBQS articles database
[Aberkane 2018]	Review the formal and the gray literature to list the main ethical issues in Computer Science	1998-2018	IEEE Xplore; Scopus
[Morley et al. 2020]	Present tools that can help machine learning developers build ethical systems	All-2019	arXiv; Google Search; PhilPapers; Scopus
[Tsamados et al. 2021]	Debate over ethical concerns and present guidance for future development in the field	2016-2020	Google Scholar; PhilPapers; Scopus; Web of Science
[Stahl et al. 2016]	Map ethical issues and discuss them and their relation	2003-2012	ISI; Scopus
[Johnson and Smith 2021]	Identify actionable interventions and tools that support ethical development of data-driven software	1996-2021	-
[Ahmad et al. 2021]	Explore existing approaches to deal with requirements engineering in the field of AI	2010-2020	ACM; Google Scholar; IEEE Xplore; Science Direct; Scopus; SpringerLink

Regarding the objectives of the analyzed studies, it is evident that there are notable differences among them. However, it is also observable that most of them focus solely on the formal literature and aim to identify concrete tools and methods to deal with ethical issues. Additionally, some works aim to facilitate discourse around these issues by compiling lists of ethical considerations, identifying relationships between them, and outlining possible future developments in the field.

Next, we present the main findings from data extraction and synthesis to answer the RQs.

RQ1. What are the main ethical issues discussed in the literature and to what extent has research covered them?

This research question aims at finding a list of ethical issues that are relevant in the literature. By doing so, we expect to bring clarity to what we mean when we talk about ethics in the field of software engineering and computer science. To answer this question, we extracted the main ethical issues pointed out by them. Some studies even presented a list of these issues based on the articles they analyzed. In Table 3 we present the scope, number of studies, and a list of the ethical issues discussed in these studies. It is evident a predominance of some topics such as Privacy and Security. These were referenced in three of the studies. Autonomy, Consent, Fairness, Responsibility, Transparency, and Trust were also relevant and were mentioned in two different studies.

Table 3. Mapping of the Secondary Studies

Studies	Scope	N° of Studies	Ethical Issues Discussed
[Almazroi 2021]	Software Usability	$9.874 \rightarrow 62$	None
[Carvalho et al. 2021]	SBQS Symposium	$518 \rightarrow 55$	Informed Consent; Ethics Committee
[Aberkane 2018]	Requirements Engineering	$680 \rightarrow 150$	Responsibility, Code of Ethics, Security, Privacy, Piracy, and Teaching Ethics
[Morley et al. 2020]	AI tools, methods and research	$+1000 \rightarrow 425$	Beneficence; Non-Maleficence; Autonomy; Justice; Explicability
[Tsamados et al. 2021]	Machine Learning	$4891 \rightarrow 118$	Inconclusive, Inscrutable, and Misguided evidence; Unfair outcomes and Transformative effects; Traceability
[Stahl et al. 2016]	Ethics & Computing	$2893 \rightarrow 599$	Privacy; Autonomy; Agency; Trust; Consent; Identity; Inclusion; Digital Divides; Security
[Johnson and Smith 2021]	Data Driven Software	-	Fairness; Accountability; Responsibility; Transparency
[Ahmad et al. 2021]	AI systems	$2.048 \rightarrow 27$	Privacy; Transparency; Trust; Reliability; Security; Fairness; Accuracy; Safety

When analyzing Tables 2 and 3, it is worth noting that the study conducted by [Johnson and Smith 2021] deviates from the standard steps of a systematic review. The authors label their work as a literature survey, but they do not provide crucial information such as the number of articles analyzed and the sources of the literature reviewed. The omission of these important details raises concerns regarding the reliability and generalizability of their findings, which could undermine the overall quality of their work.

RQ2. What are the key contributions of previous works in the field?

RQ2 aims at observing how the field is organized and present an overview of the current state of the art. To answer this question, we extracted some information from the studies, such as their scope and their main contribution specific to the field of software development. In Table 4 we can observe that the main contributions of these works were the advancement of the research literature on the theme of ethics by raising issues and deepening the debate and highlighting the need for more research, especially ones that focus on bridging the gap between theory and practice in the field. Therefore, we suggest that a secondary study that aims to find works that bridge this gap would be well placed in the literature.

RQ3. What are the primary gaps in the literature concerning ethics in software development?

Finally, this research question aims at finding gaps in the literature that could

be explored by future research. To answer this question we extracted information from the results and conclusion of the studies in which the authors listed the gaps observed by them. In Table 4 we present the main gaps found. They were related to the limited number of studies available, as well as a lack of works that provide actionable guidance for stakeholders. Finally, some works noted a growing interest in the theme in recent years, as well as consensus being formed. Some works also highlight the prevalence of debate over issues like privacy and fairness.

Table 4. Contributions, Gaps and Tendencies

Studies	Main Contributions	Gaps Identified	Tendencies Presented
[Almazroi 2021]	Pointing out the need for more discussion about ethics in the field	Lack of profound ethics discussion in the article	Need for more studies about ethics in the field
[Carvalho et al. 2021]	Highlighting that the symposium and field lack focus on the theme of ethics	Little discussion about ethics in the SBQS Symposium, which made the study analysis more complicated and less profound	Timid surge in ethics discussions lately
[Aberkane 2018]	Presenting a broader view of ethics being discussed in the formal and gray literature	Lack of tools to help developers identify ethical issues	Small surge in works exploring ethics since 2014
[Morley et al. 2020]	Outlining a typology for developers to apply ethics in ML development pipeline	Lack of incentives for ethical AI system development	Emerging consensus over how should an ethical ML system be developed
[Tsamados et al. 2021]	Expanding previous work and consolidating a framework for reviewing the debate about ethics of algorithms	Lack of criteria to properly inform developers	AI ethics discourse intensified since 2016
[Stahl et al. 2016]	Deepening computational ethics debate by grouping ethical issues, their interrelation, and discussing structural problems	Lack of actionable ethics advice for stakeholders	Privacy is a prevalent ethical issue discussed
[Johnson and Smith 2021]	Presenting research problems in translating theory to practice in software development, maintenance, and evaluation	Lack of empirical validation of existing interventions and lack of tooling that supports addressing issues beyond fairness	Tendency of dealing with the issue of fairness in the context of data-driven software
[Ahmad et al. 2021]	Raising issues in the field, mapping them, and making recommendations about future work to deal with raised issues	Lack of integration between AI systems and existing software engineering tools and methodologies	Focus on functional requirements by researchers

5. Discussions

The topic of ethics has gained increased attention in the last few years, mainly in the realm of data-driven algorithms. It is expected that this trend will continue to grow as the field of AI expands and software systems become increasingly pervasive. This tendency is evidenced by the number of studies analyzed that deal with this topic (4 out of 8). Apart from that, the low number of studies found using our research string highlights the need for more research in the field of software engineering ethics, as discussed by several of the reviewed studies. Moreover, the presented results reveal a lack of consensus in the literature, highlighting the necessity for more comprehensive studies that address both theoretical aspects and the practical implementation of ethical considerations in software system development.

In order to map the main words used in the analyzed secondary studies and extract possible relevant interrelations, we generated a word cloud (Figure 2) based on them.

Notably, "issues" and "requirements" are prominent, supporting the understanding that current works primarily focus on raising ethical issues and transforming them into requirements during the requirements engineering phase. In contrast, words like "design", "development", and "quality" receive less emphasis, indicating a gap in addressing ethics throughout other software development phases. Based on this, it is crucial to highlight that focusing solely on ethical issues during the requirements phase may hinder their effective implementation and integration into the development process and, ultimately, the final product.

Figure 2. Word cloud based on the analyzed secondary studies

This tertiary study has some limitations. The first author carried out the study selection and data extraction procedures, potentially introducing some degree of subjectivity. To mitigate this, one of the other authors also analyzed the studies returned. In addition, like all reviews, this one was constrained by the search terms utilized and the selected electronic databases. However, as this seems to be a field little explored, the studies discussed provide a snapshot of the literature on the theme. Even so, we tried to overcome this limitation by making ad-hoc research and executing a snowballing procedure in the collected studies.

6. Final Considerations

In conclusion, this study has aimed to provide a comprehensive overview of secondary studies that address ethics in the software engineering process. Our main contribution to the field is the identification of the current state of research, which highlights the nascent nature of the field and the limited number of studies that have been conducted. Many of the works reviewed underscore the need for additional research, particularly studies that bridge the gap between theoretical models and practical implementation.

Moving forward, future works must expand the scope of research to encompass the process of software development, instead of focusing on a specific technology such as AI. Additionally, a focus on practical applications of ethical values and principles would be a valuable contribution to the field. Furthermore, considering the number of studies that deal with AI and considering its black-box nature, a question remains open: how could humans intervene in the AI algorithms to make them more ethical? We hope that this study inspires further research in this important and timely area and that it will ultimately lead to a more ethically-aware approach to software engineering.

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