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Review Article

A Review: Requirements Prioritization Criteria Within Collaboration Perspective

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ABSTRACT

The attributes or criteria used in the requirements prioritization process become an essential reference in calculating priorities. Most of the techniques are used to increase the value impacting business success. On the contrary, there are limitations on cost, time, and resources for developing software. Therefore, the requirements prioritization process often requires collaboration from the perspectives involved. So far, the pattern and basis have not been seen in the criteria used in the requirements prioritization process. Consequently, there need to be other factors that become a reference so that the selection of criteria is appropriate. This study identifies criteria based on the categorized perspectives of requirements prioritization. A systematic literature review presents criteria for prioritizing requirements from multiple collaborative perspectives. Findings show that the criteria in requirements prioritization can be classified into beneficial and non-beneficial, where business value and development cost are the most frequently used criteria. Furthermore, the involvement of multiple perspectives in requirements prioritization focuses on the client's and developer's perspectives. The findings also reveal that some of the challenges in the requirements prioritization process are biases by stakeholders, reducing pairwise comparison, and scalability. In the future, it will be investigated whether the selection of criteria correlated with stakeholder perspectives will increase the accuracy of priorities. Thus, the contribution of this paper is to recommend criteria from stakeholders' perspectives.

Keywords: Aspects, client's perspective, cost-value approach, developer's perspective requirements, models, methods, prioritization criteria, techniques

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INTRODUCTION

A software requirement is a service that must exist to solve software user problems. The requirements life cycle consists of five stages: trace, maintain, prioritize, assess, and approve. These stages aim to ensure that businesses, stakeholders, and the requirements and design of a solution align (IIBA, 2015). Requirements engineering is the first step in the software development process. Play an important role so that software developers can understand the needs of stakeholders and can economically create high-quality software (Dabbagh et al., 2014). Requirements that have passed the assessment and approval stage will then enter the management process, which consists of trace, maintain, and prioritize stages. Requirements prioritization is assessing the value, urgency, and risk associated with specific requirements and designs to ensure that analysis or work is carried out at the most fundamental level on time. Limited time and resources to fulfill the requirements are important factors in the requirements prioritization process (Babar et al., 2011; Riegel, 2012; Thakurta, 2016).

In Agile requirements engineering, the value-driven approach is emphasized for product development (Schön et al., 2017). Due to increased competition, focusing on user requirements and essential delivery has become important in product development. However, the decision to carry out prioritization requirements will be more difficult when many stakeholders are involved— because different stakeholders have different perspectives. In general, the perspective on seeing requirements is based on the point of view of clients and developers (Danesh et al., 2016; Gupta & Gupta, 2018; Idrus et al., 2011; Narendhar & Anuradha, 2016). Requirements are also prioritized by looking at the relationship between benefits and costs. By calculating the cost-benefit ratio, it can be seen how much the company will pay for the features that must be made. (Torrecilla-Salinas et al., 2015). Addedly, requirements prioritization techniques are based on business and technical aspects. (Sher et al., 2019, 2014).

The process of prioritizing requirements has two sides. On the one hand, it must be fast and straightforward, and on the other hand, it must produce accurate and reliable results. Stakeholders play an essential role in the priority process. As cited in Karlsson and Ryan (1997), there are three factors in stakeholder satisfaction mentioned by Shoji Shiba and his colleagues: cost, quality, and delivery. Software project success depends on the ability to minimize costs, on time and maximize quality.

Karlsson and Ryan use relative value and cost in prioritizing requirements called the cost-value approach. This approach builds customer satisfaction from values in potential candidate requirements. In contrast, costs are expenses incurred to produce candidate requirements (Karlsson & Ryan, 1997). Requirements cannot be completely collected at the start of the project due to various factors. Therefore, continuous interaction with

clients is critical to achieving the correct requirements. The agile manifesto emphasizes collaboration among the project team and stakeholders (Sverrisdottir et al., 2014).

In software development, the popular models that have been widely used are agile development methods. One of the agile approaches is delivering value and quality within the project development budget. This objective is highly appropriate for the cost-value approach to the requirement prioritization process that compares the value and cost of software implementation. Besides the presented perspective of the agile approach, compatibility of agile and cost-value can be observed from one of the agile manifestos, which highlights "how can we honestly say that our backlog is prioritized based on what delivers VALUE for our customer?" as well as agile principles, which declare that "business people and developers must work together daily throughout the project ."This harmony rises because, in the cost-value approach, the product owner is the one who will oversee determining relative values for candidate requirements. At the same time, the software development team is assigned relative costs for implementing each one of the candidate requirements.

One of the important aspects of the requirements prioritization process is determining the criteria used. The criteria in the prioritization process will affect the success of software development. According to Sher et al., requirements prioritization aspects are categorized into three groups: technical, business, and client (Sher et al., 2019). Most requirements prioritization techniques support these aspects since they influence decision-making in requirements prioritization. However, today's trend shows that most techniques are not scalable and less supportive of business or client aspects. Riegel & Doerr divides the criteria into six main categories: Benefits, Technical Context & Requirement Characteristics, Risks, Costs, Penalties & Avoidance, and Business Context (Riegel & Doerr, 2015). Odu and Charles-Owaba believe all criteria are divided into beneficial and non-beneficial aspects. Each criterion valued is related to the pre-assigned weightage. The value is considered positive strength for the beneficial criteria and negative for the non-beneficial (Odu & Charles-Owaba, 2013).

The systematic literature review in this study focuses on the requirements prioritization domain. The nature of the project that uses requirements prioritization understudy is bespoke software with medium-level requirements (number of requirements between 20 and 50). The motivation of this study is to investigate the correlation of attributes or criteria for prioritization requirements in a cost-value approach from a collaboration perspective. The collaboration perspective is the point of view of stakeholders involved, especially clients and developers. The contribution of this study is to find the criteria used with a cost-value approach in the requirements prioritization process from the perspective of the client and developer. The following paper is organized into materials, methods, results, discussion, and conclusions.

MATERIALS AND METHODS

The correlation of attributes or criteria for requirements prioritization in a cost-value approach is investigated from a client's and developer's perspective. From the existing literature, the SLR is carried out based on the guidelines from Kitchenham (Kitchenham & Charters, 2007; Kitchenham et al., 2009).

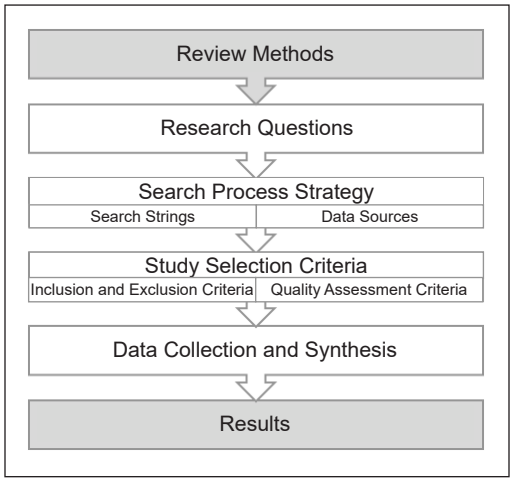


Figure 1. Review protocol

Figure 1 shows the design review protocol for performing SLRs. The protocol review consists of six research phases: research questions, search strings; resources; inclusion and exclusion criteria; quality assessment criteria; data collection and synthesis. The review methods process begins with the first phase, formulating a set of research questions to answer the research objectives. The second phase is to design a search strategy according to the research question, identify search terms and select literature data sources. The third phase is to extract the data that has been collected and assess the quality of the selected data. Finally, the fourth phase analyzes the data to answer the research objectives.

Research Questions

The primary purpose of this study is to investigate the existing research on attributes or criteria in requirements prioritization. This research is also related to the perspectives of the requirements prioritization process, the stakeholders involved, and the mapping of criteria in perspective. The following is the formulation of the questions in this study:

RQ1. What attributes or criteria are used in the requirements prioritization process?

RQ2. What perspectives are involved in requirements prioritization, and how do we classify the requirements prioritization criteria based on view?

RQ3. Who are the stakeholders that belong to each perspective?

RQ4. How are the attributes or criteria grouped in each perspective?

RQ5. What are the recommended improvements for the specified limitations or challenges?

RQ1 investigates the attributes or criteria used in requirements prioritization research. This investigation aims to find operational definitions of attributes or criteria in requirements prioritization and their popularity in the literature. RQ2 finds out what perspective is used in the requirements prioritization process and its effect on criteria. RQ3 looks for stakeholders involved in each perspective. RQ4 does a mapping between attributes or criteria with

perspectives in requirements prioritization. Finally, RQ5 provides recommendations on possible future trends in addressing the identified requirements prioritization challenges.

The Search Process Strategy

The search for papers related to this research is carried out comprehensively. The search process is carried out online in digital libraries to find papers that have been published since 2010. The following is a step-by-step procedure for conducting a search based on a predefined research question:

1. First, identify critical terms based on research questions.
2. Second, find alternative synonyms and spellings of the primary terms.
3. Third, verify the search terms of the relevant studies.
4. Finally, use the Boolean OR/AND operator to combine search terms.

Search Strings

The search string is developed in this study. The list of search strings used is as follows:

- Requirements Prioritization Models OR Framework OR Methods OR Techniques
- Cost-Value Approach for Requirements Prioritization Techniques OR Models OR Framework OR Methods
- Requirements Prioritization within Stakeholders OR Clients OR Developers Perspective OR View
- Collaborative Approach in Requirements Prioritization
- Requirements Prioritization in Agile
- Requirements Prioritization Criteria OR Attribute OR Parameter OR Aspect OR Element OR Factor
- Challenges OR Limitations OR Issues of Requirements Prioritization Models

Resources

Literature resources used in searches using the above keywords are IEEE Xplore, Elsevier, ACM Digital Library, Springer, ScienceDirect, and Google Scholar.

Based on the selected data sources, the following are the study's search and selection process steps, as illustrated in Figure 2.

Search Stage 1: In the initial stage of the search process, 360 probable selected papers are collected. The results from 6 online databases are journal articles and conference proceedings.

Search Stage 2: The merge from all resources probably has the duplicate paper, i.e., title and authors. Duplicate papers are then excluded from making sure all of them are unique. The results are 342 papers.

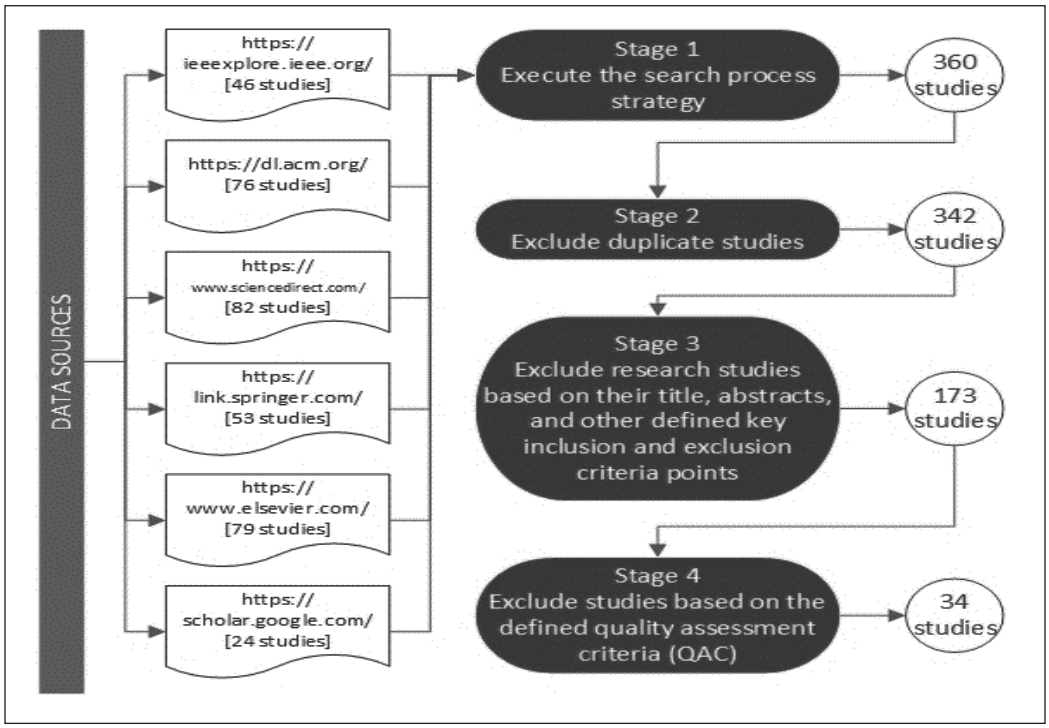


Figure 2. Stages of search and selection process

Search Stage 3: The relevant papers from the previous stage are concisely studied for their titles, abstracts, and contents. After the inclusion and exclusion are executed, 173 papers are selected.

Search Stage 4: Finally, the question or quality assessment criteria are applied to the papers selected from the previous stage. At the end of the exercise, 34 papers are selected and are considered qualified to provide answers to the research questions formulated.

Study Selection Criteria

Study selection criteria are run to identify the primary studies that directly support the research question. This strategy is to decide which literature will be included or excluded. This study is divided into two subcategories: inclusion and exclusion criteria and quality assessment criteria selected relevant.

Inclusion and Exclusion Criteria

Three hundred sixty studies are collected during the initial search process. First, the title and abstract are read carefully, and then studies not related to requirements prioritization are excluded. If there are several similar studies, the study that discusses it in full will be

taken. The studies taken are in English and have been published since 2010. The detailed inclusion and exclusion criteria used in this SLR are shown in Table 1.

Table 1
Inclusion and exclusion criteria

INCLUSION CRITERIA	EXCLUSION CRITERIA
Research work focuses on requirements prioritization criteria OR perspective. Studies included those whose title corresponded with the research topic with a keyword related in a formulated search string. All studies have the prospect of answering at least one research question. Relevant studies have been published since 2010. All studies are published in the English language.	Studies that are unrelated to the research questions Duplicate studies, only the newest and most complete, will be included. The rest are excluded. Studies that are not written and published in English. All studies are considered grey and do not have bibliographic details such as publication type/ date.

Quality Assessment Criteria

Quality Assessment Criteria (QAC) help assess the quality of the selected topic. The assessment of the selected topic was carried out based on QAC quality questions that are related to the domain of this study. The QAC checklist consists of six questions. These questions are presented in Table 2. The answer to each question can be 'Yes,' 'Partially,' or 'No.' The values are 1, 0.5, and 0.

To ensure the reliability of the study, studies that obtained a quality score of more than or equal to three, which is half of the total scores, will be used (6). As a result, from 173, only 34 studies are finally selected as relevant studies. The results of the quality scores of each study are shown in Figure 3.

Table 2
Quality assessment criteria

ID	QUESTION
QAC1	Are the review's inclusion and exclusion criteria represented and suitable?
QAC2	Does the study focus on the requirements prioritization domain?
QAC3	Does the study illustrate the requirements prioritization criteria?
QAC4	Is the proposed model/solution/ technique clearly described?
QAC5	Were the basic data/studies sufficiently explained?
QAC6	Is the result of the research clearly stated?

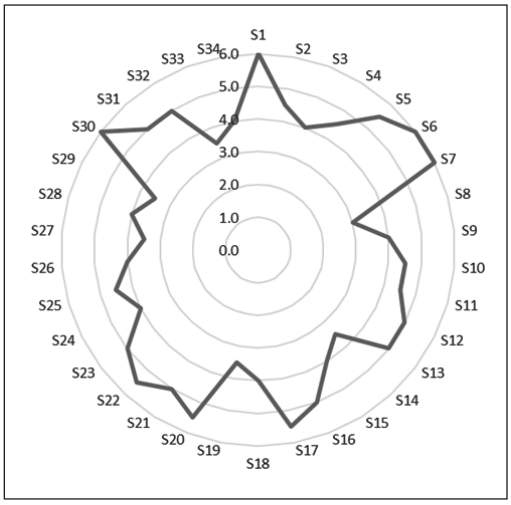
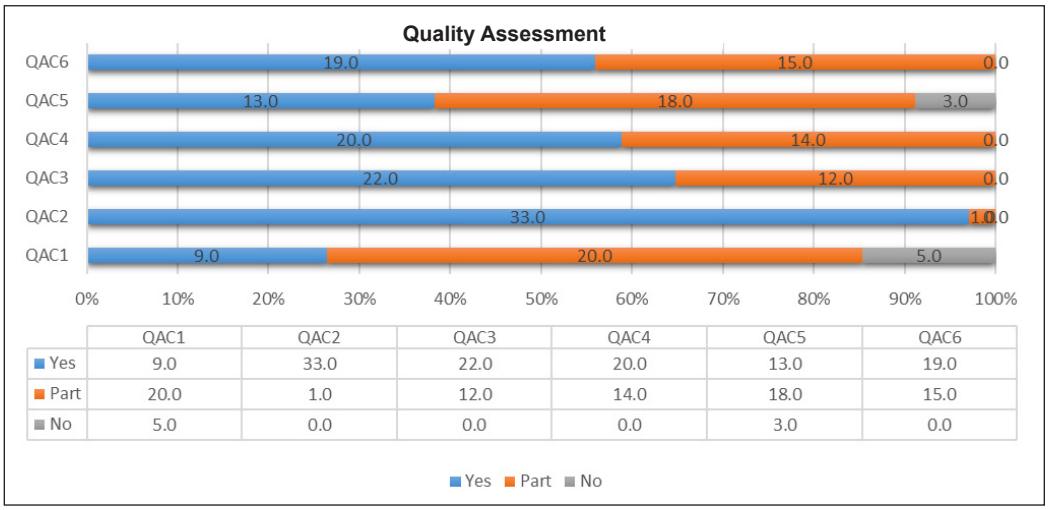


Figure 3. The results of quality scores from the selected studies

Based on Figure 3, from a score of 0 to a score of 6, only one paper, S8, gets a score of 3, while others get higher than 3. Figure 4 shows the number of studies that have answered yes, part or no to each question in QAC.

From 34 studies selected, only QAC1 and QAC5 questions have the "No" (0) result. These results mean that most of the papers can meet the questions of quality assessment criteria.



	QAC1	QAC2	QAC3	QAC4	QAC5	QAC6
Yes	9.0	33.0	22.0	20.0	13.0	19.0
Part	20.0	1.0	12.0	14.0	18.0	15.0
No	5.0	0.0	0.0	0.0	3.0	0.0

Figure 4. Quality assessment

Data Collection and Synthesis

From 34 selected papers, the main data extracted are: title, year of publication, authors, criteria/ parameter/ aspect/ element/ factor. In this process, the difficulty encountered is that the names of different criteria are often encountered but have the same meaning. The problem with clarifying criteria is to explore whether these different criteria names have the same understanding or are different in prioritization.

In data synthesis, quantitative and qualitative data analysis approaches are used. The data that have been collected are analyzed by focusing on research questions. RQ1 explores the criteria used in the requirements prioritization process. Then to answer RQ2, look for the perspective used in the paper and its effect on the criteria used. The stakeholders involved are then explored to be able to answer RQ3. Furthermore, to answer RQ4, map or group the criteria based on perspective. The last is to do a resume to answer RQ5 regarding the recommended improvements in the process of requirements prioritization criteria.

RESULTS AND DISCUSSIONS

Based on 34 identified papers, Figure 5 shows the number of papers published each year. Two papers present the SLR results to find the criteria used in the prioritization

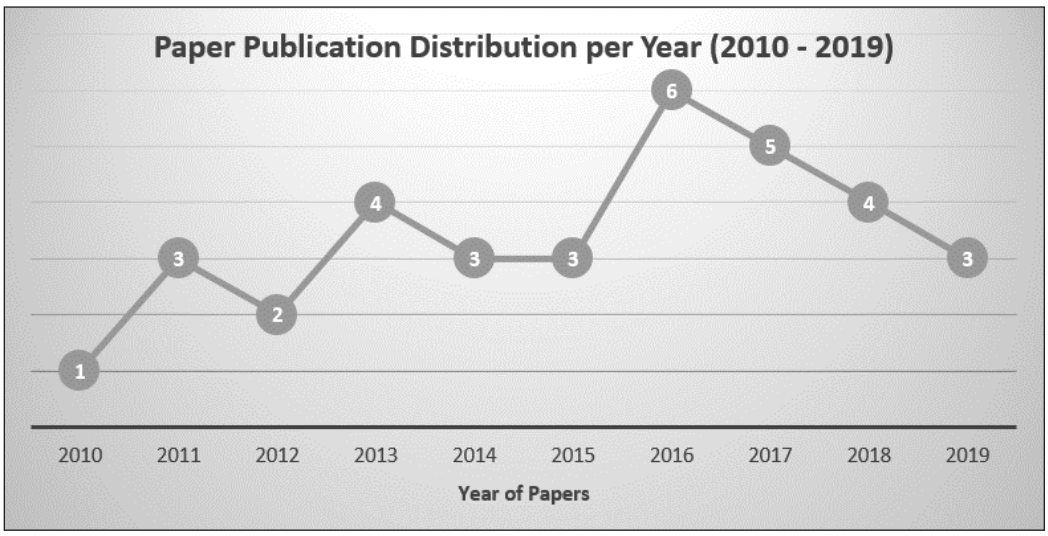


Figure 5. Papers published by year

requirements: Riegel and Doerr (2015) and Hujainah et al. (2018). Only the top ten criteria are taken from the study from these two papers.

(RQ1) What are the Attributes or Criteria Which are Used in the Requirements Prioritization Process?

Some attributes or criteria are mentioned or used in papers that meet the requirements. Of the 38 identified criteria, several criteria have different names but have the same meaning and purpose. For example, the criteria for "business value" are also called: "value," "customer value," and "value to user." "Development cost" is also called: "development effort." "cost," and "budget." "Time to market" is also known as: "release date," "time," and "timely delivery." "Available of resources" is also called: "resource availability," "human resources," and "manpower." Table 3 shows all the criteria found and their operational definitions.

The frequency of the criteria used or mentioned in the SLR paper can be seen in Figure 6. The frequency here indicates the number of papers in this study that use these criteria. The use of criteria in the requirements prioritization process is very diverse. Thus, many criteria are used in the literature when collected. This study finds 38 criteria, from the few frequencies (only once or twice mentioned) to the favorite criteria, such as business value and development cost. The business value has been mentioned 30 times, development cost has been mentioned 23 times, risk has been mentioned 16 times, and time to market has been mentioned 15 times. Furthermore, dependency has been mentioned nine times, followed by available resources, effort estimation/size measurement, and schedule, which have been mentioned eight times. The criteria with a frequency of seven

Table 3
The criteria of requirements prioritization

ID	CRITERIA	CITATION	OPERATIONAL DEFINITION
C1	**Business Value**	Al-Ta'ani & Razali, 2016; AL-Ta'ani & Razali, 2013; Alawneh, 2018; Albuga & Odeh, 2018; Alkandari & Al-Shammeri, 2017; Anand & Dinakaran, 2017; Asghar et al., 2017; Devulapalli et al., 2016; Devulapalli & Khare, 2014; Gupta & Gupta, 2018; Hujainah et al., 2018; Khan et al., 2016; Kukreja, 2013; Kukreja et al., 2012; Narendhar & Anuradha, 2016; Racheva et al., 2010; Rahim et al., 2018; Riegel & Doerr, 2015; Sheemar & Kour, 2019; Sher et al., 2019; Sufian et al., 2019; Sureka, 2014; Thakurta, 2012; Torrecilla-Salinas et al., 2015; Viswanathan et al., 2016	Business value is the entire value that delivers profit to the organization to increase revenue, improve service, or avoid costs.
C2	**Development Cost**	Al-Ta'ani & Razali, 2016; AL-Ta'ani & Razali, 2013; Alawneh, 2018; Alkandari & Al-Shammeri, 2017; Amiri & Golozari, 2011; Anand & Dinakaran, 2017; Asghar et al., 2017; Bajaj & Arora, 2013; Devulapalli & Khare, 2014; Hujainah et al., 2018; Idrus et al., 2011; Kukreja, 2013; Kukreja et al., 2012; Narendhar & Anuradha, 2016; Rahim et al., 2018; Riegel & Doerr, 2015; Samarakoon & Ratnayake, 2015; Sher et al., 2019; Sufian et al., 2019; Sureka, 2014; Thakurta, 2012; Torrecilla-Salinas et al., 2015; Viswanathan et al., 2016	The cost an organization incurs while developing a software product.
C3	**Time To Market**	Alkandari & Al-Shammeri, 2017; Amiri & Golozari, 2011; Asghar et al., 2017; Bajaj & Arora, 2013; Devulapalli et al., 2016; Devulapalli & Khare, 2014; Idrus et al., 2011; Khan et al., 2016; Sheemar & Kour, 2019; Sher et al., 2014; Sufian et al., 2019; Svensson et al., 2011; Tahvili et al., 2015; Viswanathan et al., 2016	During the period needed, the development team does every task until it is released to the market.
C4	**Risk**	AL-Ta'ani & Razali, 2013; Alkandari & Al-Shammeri, 2017; Amiri & Golozari, 2011; Anand & Dinakaran, 2017; Asghar et al., 2017; Hujainah et al., 2018; Khan et al., 2016; Narendhar & Anuradha, 2016; Racheva et al., 2010; Rahim et al., 2018; Sufian et al., 2019; Svensson et al., 2011; Tahvili et al., 2015; Thakurta, 2012; Viswanathan et al., 2016	Risk is the probability of software failure. It refers to the business and technical risks associated with implementing the requirements in the given scenario.

Table 3 *(continue)*

ID	CRITERIA	CITATION	OPERATIONAL DEFINITION
C5	**Dependencies**	Al-Ta'ani & Razali, 2016; AL-Ta'ani & Razali, 2013; Anand & Dinakaran, 2017; Asghar et al., 2017; Gupta & Gupta, 2018; Hujainah et al., 2018; Riegel & Doerr, 2015; Sureka, 2014; Viswanathan et al., 2016	Requirements dependency is the relationship between requirements that depends on the others.
C6	**Available of Resources**	AL-Ta'ani & Razali, 2013; Alkandari & Al-Shammeri, 2017; Anand & Dinakaran, 2017; Danesh et al., 2016; Devulapalli et al., 2016; Devulapalli & Khare, 2014; Riegel & Doerr, 2015; Sureka, 2014	Availability of development resources, knowledgeable in domain/ technology/ skill.
C7	**Effort Estimation/ Size Measurement**	Al-Ta'ani & Razali, 2016; Alkandari & Al-Shammeri, 2017; Bajaj & Arora, 2013; Danesh et al., 2016; Hujainah et al., 2018; Kukreja et al., 2012; Racheva et al., 2010; Torrecilla-Salinas et al., 2015	In the effort process, estimation difference is computed between total available effort and effort required for software releases, and this job is done by technical and development teams.
C8	**Schedule**	Al-Ta'ani & Razali, 2016; AL-Ta'ani & Razali, 2013; Alkandari & Al-Shammeri, 2017; Kukreja, 2013; Kukreja et al., 2012; Samarakoon & Ratnayake, 2015; Sureka, 2014; Torrecilla-Salinas et al., 2015	The project schedule is a project's timeframe. It includes start and finish dates, activities, and deliverables and lists all project-related milestones.
C9	**Volatility**	AL-Ta'ani & Razali, 2013; Alkandari & Al-Shammeri, 2017; Anand & Dinakaran, 2017; Devulapalli & Khare, 2014; Rahim et al., 2018; Riegel & Doerr, 2015; Svensson et al., 2011	Requirements Volatility is frequent changes to the requirements over time.
C10	**Implementation Effort**	Devulapalli et al., 2016; Devulapalli & Khare, 2014; Khan et al., 2016; Riegel & Doerr, 2015; Sureka, 2014; Tahvili et al., 2015; Viswanathan et al., 2016	Costs are needed for implementation until the source code commit.
C11	**Importance**	AL-Ta'ani & Razali, 2013; Alkandari & Al-Shammeri, 2017; Asghar et al., 2017; Danesh et al., 2016; Hujainah et al., 2018; Sureka, 2014; Svensson et al., 2011	The important requirements are functions that bring an organization business value.
C12	**Stakeholder Satisfaction**	Hujainah et al., 2018; Narendhar & Anuradha, 2016; Riegel & Doerr, 2015; Sher et al., 2014; Svensson et al., 2011; Tahvili et al., 2015; Viswanathan et al., 2016	Fulfill the expectations of stakeholders that can achieve their personal goals and objective.
C13	**Complexity**	Al-Ta'ani & Razali, 2016; AL-Ta'ani & Razali, 2013; Anand & Dinakaran, 2017; Asghar et al., 2017; Tahvili et al., 2015	The complexity and interdependencies to streamline product development with challenges complicate the selection.

Table 3 *(continue)*

ID	CRITERIA	CITATION	OPERATIONAL DEFINITION
C14	**Quality**	Amiri & Golozari, 2011; Idrus et al., 2011; Sheemar & Kour, 2019; Tahvili et al., 2015; Torrecilla-Salinas et al., 2015	Quality refers to a capability that must be present in a requirement. Quality represents what is needed to validate the successful completion of a project deliverable.
C15	**Penalty**	Asghar et al., 2017; Hujainah et al., 2018; Svensson et al., 2011; Thakurta, 2012	The customer or business will likely experience penalties if specific requirements are not included in the scenario.
C16	**Authority**	AL-Ta'ani & Razali, 2013; Anand & Dinakaran, 2017; Samarakoon & Ratnayake, 2015; Sher et al., 2014	The requirements priorities are best determined by clients who have dominion over the system.
C17	**Learning Experience**	AL-Ta'ani & Razali, 2013; Alkandari & Al-Shammeri, 2017; Racheva et al., 2010	The learning experience is risky because the developer will need more time to learn new technology.
C18	**Impact**	Devulapalli et al., 2016; Devulapalli & Khare, 2014	The impact of the characteristics of the product or service on the intended beneficiaries.
C19	**External Change**	Racheva et al., 2010; Alkandari & Al-Shammeri, 2017	External changes are the "events that occur during the project and impact the company, the business environment or the product under development."
C20	**Knowledge**	AL-Ta'ani & Razali, 2013; Anand & Dinakaran, 2017	Stakeholders must have significant knowledge of development and customer needs and interest.
C21	**Strategic**	Sher et al., 2014; Svensson et al., 2011	A strategic requirement is something an organization sets out to achieve.
C22	**Scalability**	Sher et al., 2014; Asghar et al., 2017	The ability to appropriately handle increasing (and decreasing) requirements.
C23	**Usability**	Hujainah et al., 2018; Sheemar & Kour, 2019	Usability refers to producing systems that are easier to use and matching them more closely to user requirements.
C24	**Technical Feasibility**	Kukreja et al., 2012; Samarakoon & Ratnayake, 2015	Technical feasibility also implicates evaluating the proposed system's hardware, software, and other technical requirements.
C25	**Customer Input**	Sher et al., 2019	To use client input as criteria for prioritization.
C26	**Performance**	Bajaj & Arora, 2013	Requirement performance represents how well a process is to be executed or performed or how well it is accomplished.
C27	**Uncertainties**	Devulapalli & Khare, 2014	Changes imminent.
C28	**Easy Use**	Sher et al., 2014	How easily users can use a product.
C29	**Accuracy**	Sher et al., 2014	The provision of right or effects attributes or agreed results.

Table 3 *(continue)*

ID	CRITERIA	CITATION	OPERATIONAL DEFINITION
C30	**Developers' Input**	Alkandari & Al-Shammeri, 2017	How easily users can use a product.
C31	**Negative Value**	Alkandari & Al-Shammeri, 2017	The 'negative' value thus is equivalent to a loss of importance or damage to the business.
C32	**Visibility**	Al-Ta'ani & Razali, 2016	A lack of visibility prevents teams from taking appropriate action, leading to uncontrollable impediments later in the sprint.
C33	**Trust**	AL-Ta'ani & Razali, 2013	Stakeholders must have direct communication to achieve trust.
C34	**Sales**	Sher et al., 2014	Sales Impact.
C35	**Marketing**	Sher et al., 2014	Most aspects of your business depend on successful marketing.
C36	**Applicability**	Samarakoon & Ratnayake, 2015	Applying or capable of being applied.
C37	**Reliability**	Samarakoon & Ratnayake, 2015	This quality attribute defines how likely the system would run without failure.
C38	**Urgency**	Gupta & Gupta, 2018	Urgency of implementation.

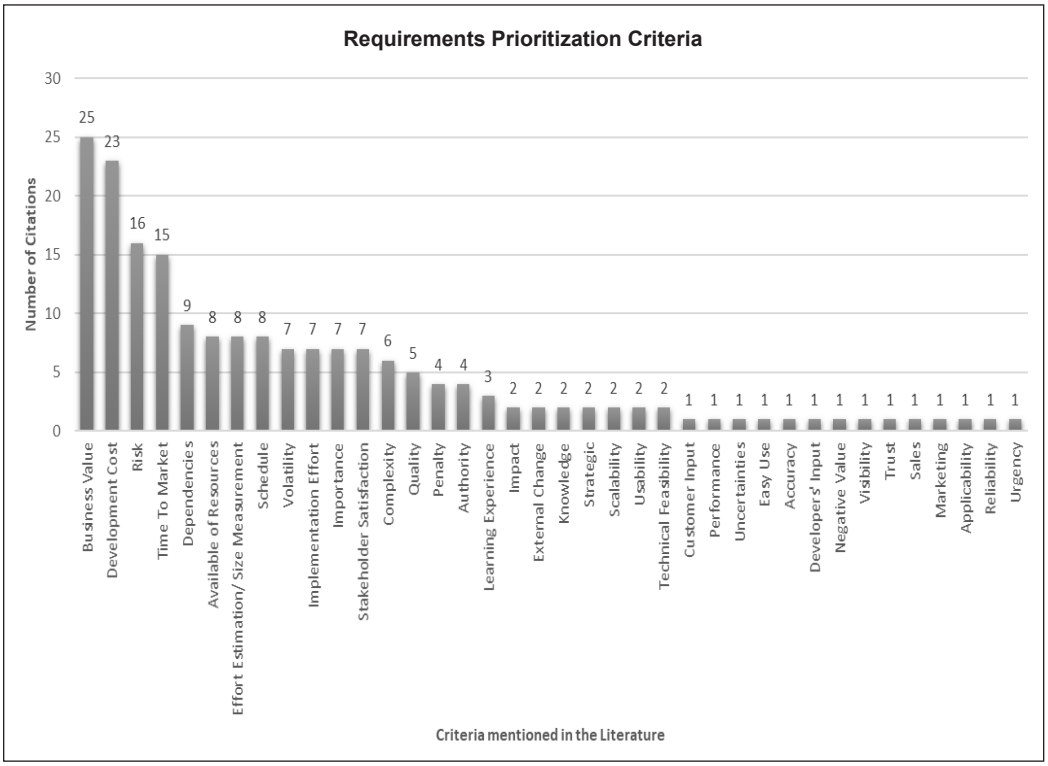


Figure 6. The usage frequency of requirements prioritization criteria

consist of volatility, implementation effort, importance, and stakeholder satisfaction. In addition, quality was mentioned five times, penalty and authority were mentioned four times, followed by learning experience, which was mentioned three times. The criteria mentioned twice are impact, external change, knowledge, strategy, scalability, usability, and technical feasibility. Finally, the remaining criteria show a frequency of 1: customer input, performance, uncertainties, ease of use, accuracy, developer's input, negative value, visibility, trust, sales, marketing, applicability, reliability, and urgency.

(RQ2) What are the Perspectives Involved in Requirements Prioritization, and How to Classify the Requirements Prioritization Criteria Based on View?

Requirements from stakeholders represent the needs from an individual point of view. The term perspective emphasizes that there is no simple relationship between requirements and people or between requirements and roles. A perspective is an area of knowledge that is internally consistent. Perspectives usually have an identifiable focus of attention, the motivational concern of the requirements they represent (Easterbrook, 1991).

In software development projects, there are many people along with roles that have perspectives, respectively. The success of a requirements engineering project depends on an accurate analysis of this perspective for incompleteness and inconsistency. Many papers mention that the involvement of perspectives is very important and affects the requirements prioritization process (Alkandari & Al-Shammeri, 2017; Gupta & Gupta, 2018; Ibriwesh et al., 2019; Idrus et al., 2011; Madi et al., 2013; Narendhar & Anuradha, 2016; Schön et al., 2017; Sher et al., 2019, 2014; Wohlin & Aurum, 2005).

As for the perspectives used by SLR, most do not explicitly mention the view used. For example, there are only eight papers identified mention the perspective used in the study (Alkandari & Al-Shammeri, 2017; Danesh et al., 2016; Gupta & Gupta, 2018; Idrus et al., 2011; Narendhar & Anuradha, 2016; Sher et al., 2019, 2014; Torrecilla-Salinas et al., 2015). To expand the extent to which the use of perspective in the requirements, Table 4 shows the addition of a source of books on engineering requirements.

The influence of perspective on the criteria used in the requirements prioritization process is closely related to the point of view. There are big groupings in perspective, namely, the client's perspective and the developer's perspective.

Table 4
Requirements prioritization perspective

#	PERSPECTIVE	DEFINITION	TYPE OF CITATION	
			PAPER	BOOK
GROUP OF CLIENTS' PERSPECTIVES				
1	Clients	The product, according to the client's needs	Gupta & Gupta, 2018; Danesh et al., 2016; Idrus et al., 2011	

Table 4 *(continue)*

#	PERSPECTIVE	DEFINITION	TYPE OF CITATION	
			PAPER	BOOK
2	Customers	Care about the user/customer value to determine whether they describe the desired functions and qualities of the system	Alkandari & Al-Shammeri, 2017	Aurum & Wohlin, 2005; Wiegers, 2009
3	User	Comparable to the owner's view of a house		Pohl & Rupp, 2015; Wieringa, 1996
4	Stakeholders	State what the stakeholders are required to achieve by the system	Narendhar & Anuradha, 2016	Hull et al., 2011
5	Top Manager	It represents the product idea		Wieringa, 1996
6	Business	To decide whether the business really needs the system	Sher et al., 2014; Sher et al., 2019	Sommerville, 2016
GROUP OF DEVELOPERS' PERSPECTIVES				
7	Developers	Know about the technical difficulties	Gupta & Gupta, 2018; Danesh et al., 2016; Idrus et al., 2011; Narendhar & Anuradha, 2016; Alkandari & Al-Shammeri, 2017	Aurum & Wohlin, 2005
8	Software Architect	To ascertain if they contain all necessary information for architectural design		Pohl & Rupp, 2015
9	Analyst	State abstractly what the system will do to fulfill the stakeholder requirements		Hull et al., 2011
10	Designer	State how the specific design will fulfill the system requirements. Comparable to the specification delivered by the architect for the designer		Hull et al., 2011; Wieringa, 1996
11	Technical	To assess the quality of the application software and the system's support software and hardware	Sher et al., 2014; Sher et al., 2019	Wiegers, 2009; Sommerville, 2016
12	Builder	The technology model		Wieringa, 1996
13	Tester	To establish whether they contain the information necessary to derive test cases from the requirements		Pohl & Rupp, 2015
14	Financial Representative	Know and manage budgetary limitations and risks		Aurum & Wohlin, 2005

(RQ3) Who are the Stakeholders that Belong to Each Perspective?

Stakeholders of the system are people or organizations that directly or indirectly affect the system requirements. To obtain requirements, stakeholders are one type of requirements source other than documents and systems in operation (Pohl & Rupp, 2015). Therefore, identifying relevant stakeholders is important in requirements engineering. If stakeholders are not recognized will result in a significant negative impact on the success of the project. In practice, there may be many stakeholders involved. Still, Requirements Prioritization should differentiate the involvement of stakeholders, whether only being affected by the project or being a collaborator (integrated and responsible with stakeholders). The list of stakeholders involved in requirements prioritization can be seen in Table 5.

(RQ4) How are the Attributes or Criteria Grouped in Each Perspective?

RQ4 aims to classify the attributes or criteria obtained from the RQ1 results. The cost-value approach is a process of prioritizing software requirements to maximize quality, minimize costs, and the shortest possible delivery time, according to the relative value and cost based on the Analytic Hierarchy Process (AHP) analysis tool (Amelia & Mohamed, 2018; Karlsson & Ryan, 1997; Karlsson et al., 1997; Sie, 2016). AHP and TOPSIS are methods in Multi-Criteria Decision Making (MCDM) that are often used and combined.

The attributes or criteria in the MCDM are divided into two types: beneficial and non-beneficial. For example, attributes whose value must be kept low are non-beneficial attributes, and other attributes which must have higher value are beneficial attributes. Another name for beneficial attributes is favorable indicators, while non-beneficial attributes are unfavorable indicators. If related to the criteria, use the beneficial attributes from the client's perspective and the developer's perspective using non-beneficial attributes.

Table 3 is based on the cost-value approach, which is classified as beneficial attributes and non-beneficial attributes, with the results shown in Table 6. In the process of priority needs, the attributes or criteria used in most of the papers are non-beneficial rather than beneficial attributes.

The criteria in the prioritization requirements are grouped into project constraints in some literature (AL-Ta'ani & Razali, 2013; Alkandari & Al-Shammeri, 2017; Nurdiani et al., 2016). Project constraints are constraints on specific parameters that affect the results (Thakurta, 2016). Some studies include "project constraints" as one of the criteria, which is ambiguous. For example, the development cost is a criterion that limits the project because of the different abilities of each project owner to cover the costs. On the other side, the business value is not a project constraint because this criterion does not restrict the development of a project. In addition, most of the criteria used in beneficial attributes are not project constraints.

Table 5
Stakeholders in a requirements prioritization process

#	STAKEHOLDERS OF CLIENTS' PERSPECTIVE	CITATION	#	STAKEHOLDERS OF DEVELOPERS' PERSPECTIVE	CITATION
1	End Users	Shukla & Auriol, 2013; Lim et al., 2013; Hujainah et al., 2018); Pohl & Rupp, 2015); Hull et al., 2011; Chemuturi, 2013; Wiegers, 2009); Wieringa, 1996; Laplante, 2017; Sommerville, 2016)	1	Developers	Kaiya et al., 2005; Bendjenna et al., 2012); Heikkila et al., 2015; Lim et al., 2013; Hujainah et al., 2018; Sadiq & Jain, 2013; Pohl & Rupp, 2015; Aurum & Wohlin, 2005; Chemuturi, 2013; Wiegers, 2009; Wieringa, 1996; Laplante, 2017
2	Operators	Sadiq & Jain, 2013; Pohl & Rupp, 2015	2	Software Architects	Dos Santos et al., 2016; Heikkila et al., 2015; Hujainah et al., 2018; Pohl & Rupp, 2015; Sommerville, 2016)
3	Customers / Sponsor	Dos Santos et al., 2016; Kaiya et al., 2005; Bendjenna et al., 2012; Heikkila et al., 2015; Lim et al., 2013; Hujainah et al., 2018; Sadiq & Jain, 2013; Pohl & Rupp, 2015; Aurum & Wohlin, 2005; Chemuturi, 2013; Wiegers, 2009); Laplante, 2017; Sommerville, 2016	3	Technical Engineer	Shukla & Auriol, 2013; Hujainah et al., 2018; Wieringa, 1996; Laplante, 2017; Sommerville, 2016
4	Business Analyst	Shukla & Auriol, 2013; Hujainah et al., 2018; Kukreja et al., 2012	4	System Designers	Hujainah et al., 2018; Wieringa, 1996; Laplante, 2017
5	Managers	Hujainah et al., 2018; Hull et al., 2011; Sommerville, 2016	5	Requirements analysts	Dos Santos et al., 2016; Hujainah et al., 2018; Wiegers, 2009
6	Financial Representatives	Sadiq & Jain, 2013; Aurum & Wohlin, 2005	6	Programmers	Hujainah et al., 2018; Wieringa, 1996; Laplante, 2017
7	Maintenance and service staff	Hull et al., 2011; Laplante, 2017	7	Project managers	Heikkila et al., 2015; Hujainah et al., 2018; Kukreja et al., 2012; Wiegers, 2009; Wieringa, 1996
8	Sales and Marketing	Hujainah et al., 2018; Hull et al., 2011; Chemuturi, 2013; Wiegers, 2009	8	Business Engineer	Hujainah et al., 2018
9	Government	Hull et al., 2011; Laplante, 2017	9	Testers	Pohl & Rupp, 2015; Wiegers, 2009
10	Organizational Standards Group	Hull et al., 2011; Laplante, 2017			
11	Regulatory authorities	Lim et al., 2013; Hull et al., 2011			

Table 6
The correlation attributes based on perspectives

CLIENTS PERSPECTIVE		
BENEFICIAL ATTRIBUTES (37%)	**Project Constraints (No)**	Business Value, Importance, Stakeholder Satisfaction, Authority, Knowledge, Strategic, Usability, Customer Input, Performance, Easy Use, Accuracy, Customer Input, Visibility, Sales, Marketing, Applicability, Reliability, Urgency
	Project Constraints (Yes)	Quality, Impact, Scalability, Trust
DEVELOPERS PERSPECTIVE		
NON-BENEFICIAL ATTRIBUTES (63%)	**Project Constraints (No)**	Effort Estimation/ Size Measurement, Penalty, Learning Experience, External Change, Technical Feasibility, Uncertainties, Developers' Input, Negative Value
	Project Constraints (Yes)	Development Cost, Risk, Time to Market, Dependencies, Available of Resources, Schedule, Volatility, Implementation Effort, Complexity

(RQ5) What are the Recommended Improvements for the Specified Limitations or Challenges?

The requirements prioritization process involving many parties has challenges: inaccuracy, time consumption, and ease of use. However, there are open opportunities to improve the weaknesses that still exist with the increase in requirements prioritization models. Some points that issues can add to the requirements prioritization domain include:

- Bias issues by stakeholders due to the many stakeholders involved, without considering the perceptions of stakeholders (Philip et al., 2014; Babar et al., 2015; Bakhtiar et al., 2015; Hannan et al., 2015; Khan et al., 2016; McZara et al., 2015). The result of requirements prioritization can perform accuracy using fuzzy numbers and give proper weighting based on stakeholders' perceptions.
- Requirements Prioritization must address the issue of reducing pairwise comparisons to minimize time consumption (Gambo et al., 2018; Karlsson et al., 1998). AHP only provides attribute weighting, while TOPSIS is used to calculate alternatives to facilitate pairwise comparison.
- Attribute weighting while calculating alternatives using TOPSIS.
- Scalability issues related to the ease of prioritization requirements should be further improved, regardless of the requirements (Achimugu et al., 2014; Achimugu et al., 2016; Babar et al., 2015; Duan et al., 2009; Gambo et al., 2018; Khan et al., 2016; Lim & Finkelstein, 2012; Veerappa, 2012). Meanwhile, prioritization can be done by making tools to facilitate the needs.

CONCLUSION

Attributes or criteria in the prioritization requirements are fundamental things that must be selected. This study conducted a comprehensive investigation on the criteria that are widely used in the prioritization requirements. The resulting criteria can help researchers or practitioners to choose criteria that suit their needs and increase the accuracy of the chosen ones so that the results of the requirements prioritization can be more accurate. The involvement of stakeholder perspectives in the requirements prioritization process is a collaboration between the client's and the developer's perspectives. The findings suggest that future research needs to consider the selection of criteria from stakeholders' perspectives.

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