Chapter

Total Quality Management of Research Articles in Electrical Engineering

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Abstract

Recently, the quality management of research articles (RA) has cherished an era of remarkable growth and conglomeration. It is because the qualitative approach has become an established and valued approach among varietal areas and contexts. The quality of RA is precisely based on the clarity of the illustration of the aims. Previously, the categorical analysis of RA has been restricted to the format of writing the article following Introduction-Process-Testing-Conclusion (IPTC) or Introduction-Methodology-Result-Discussion (IMRD) standards. But the wholesome strategy of Total Quality Management (TQM) of RA has not been demonstrated from the core in the discipline of Electrical Engineering (EE). The research question, sample, control of staggering variables, research designs, criteria measures, data analysis, ethics, discussions, references are the critical collectibles (CCs) on what matters to the readers of RA. The macrostructures of EE-RA, features of each sector of EE RA, section headlines, extension of description and prominent aspects were analyzed for hundred RA from fifteen journals of EE. These features are compared with respect to all the CCs. This chapter helps to recognize the necessary inputs for TQM implementation with different proactive journals of EE to improve the quality of RA.

Keywords: electrical engineering, critical collectibles, research articles, total quality management, survey

1. Introduction

The research articles (RA) may have excellent process of analysis management and tools to ensure strength of the study. However, analysis management alone cannot ensure the readers' satisfaction. Total Quality Management (TQM) is an approach to not only ensure high quality of an experimental and developmental research but to accomplish the higher levels of readers' satisfaction.

To keep up the relevant level of quality of any research, all the features and tasks of RA are needed to be monitored. The strategy of TQM involves the target of achieving pre-defined benchmark standards of quality through the formulation of policy, planning, assurance and control of quality advancement.

The macrostructure of RA in science stream has been described by Harmon in [1]. The Introduction-Methodology-Result-Discussion (IMRD) standard had been set for describing the experimental kind of research. However, this standard was found to be incompetent for engineering stream [2]. Harmon also categorized engineering RA into theoretical and developmental standards. The overall TQM implementation in developmental or theoretical RA of engineering stream seem to receive slight attention, even though articles related to engineering stream typically contributes towards the development or advancement of novel solution to a particular problem [3]. A different macrostructure standard named as, Introduction-Process-Testing-Conclusion (IPTC), has been recently claimed to the prototypical standard for RA related to EE [4].

The subfields or sectors of EE are related to fields of computer engineering, power engineering, signal processing, photovoltaic cells, system engineering, telecommunications, radio-frequency engineering, instrumentation, optics, electronics and photonics. Most of these fields observes the overlapping with other engineering sectors. There are thousands of RA pertaining explicitly to EE subfields. From the point of view of themes of EE, the topics are categorized into electromagnetism, physical laws, control engineering, electronics, power engineering, electric vehicles, signal processing, instrumentation and telecommunication.

This chapter analyzes hundred RA in fifteen journals of EE to acknowledge their quality check with respect to CC measures of TQM. The distinctive aspects about the different approaches addressed for implementation of TQM are also described. The chapter is organized in the form of sections, given as follows. The 'literature survey' section presents that the RA from all fields of EE in almost all the journals are peer-reviewed. The 'research methodology' section presents the complexity of analyzing the representative corpus of articles in EE and the techniques used in this work. The 'analysis results and remarks' section shows that although the quality management is executed through very transparent approach while analyzing an article but from the point of view of reviewers and readers of articles in EE, this task is somewhat subjective. It also represents that how the quality assessment approach has evolved over the years and the discussion of pedagogical implications respectively, followed up by a comprehensive conclusion.

2. Literature survey

There are various genres that are perceived within the field of engineering [5]. However, this research concentrates on the full length RA in one or two step peer-reviewed journal. A significant amount of work has been reported in literature related to the framework of genre analysis.

The New Rhetoric variant of genre analysis is a kind of inter-disciplinary field technique used for introducing broad way of argumentation of classical canons of rhetoric, which are structure of content (arrangement), language (style), background (memory), what to say (invention) and delivery (presentation).

The Systematic Functional Linguistic (SFL), originally designed by M. Halliday, uses the idea of developing analytical categories of language. According to SFL, language is the means of social parole system. SFL provides a convenient tool to analyze RA by emphasizing the functional base of structure of language.

Another variant of genre analysis is English for Specific Purpose (ESP) [6]. Generally, it refers to the subset of the language learning in accordance to the enhancement of vocabulary or the skills of the author of the articles.

The above mentioned variants of genre analysis are few important measures used for carrying out the review process of an article. The articles following the ESP custom are first reviewed in this section. Through the survey, it is demonstrated that the earlier RA are first examined on the basis of macrostructure. Then, it is researched that the field of electrical engineering is considered as that of applied science, due to which the wholesome strategy of TQM implementation may have prevented.

Using the analysis done by Harmon, through diversity in engineering RA, it was found out that the articles are mostly 'experimental' exhibiting a certain confined structure. Such structures include heading (i.e., title and/or subtitle), abstract, introduction, methodology, experimental specifics, results, explanation, conclusion, acknowledgements and references. The quality check of the articles used to be done on the basis of research work done and the explanation of the basic theory associated to the work. However, it is found that only macrostructure cannot be always enough for maintaining the quality management of the RA.

In applied linguistic [7–8], the secondary RA commonly consist of non-standard headings of the subsections. Such headings or titles of the sections in an article can be one of the distinguishing features in different fields. The RA, following IMRD structure, consists of deductive or hypothetical procedures of science. Whereas, those articles, which follow the IPTC structure, demonstrate the problem solving techniques of science [9]. In the field of information systems or computer science, the RA are structured in the form of one add-on section or replacement of the 'methodology' section by a new heading called 'algorithm' or 'application' or 'implementation process, system or program' [10].

In [11], by examining RA related to thirty-nine disciplines, Lin et al. discovered seven variants of IMRD macrostructure for each discipline of engineering disciplines. The modeling of ESP scholars' adopting the canonical IMRD structure, results in rise of the limitations of the related analyses [11] which degrades quality of corresponding RA. Lin et al. defined the RA which contain "empirical design", "research and data design", "experimental" or "the study" types of variants in Heading method are called experimental papers. However, few from such papers fit the description of adoption of such macrostructure. It is because the data results of few RA establish actual variability. This is justified by distinguishing 'experimental' RA from 'review' and 'theoretical' RA. So, the quality of macrostructure needs to be subdivided into separate categories depending upon the quality of content rather than their headings in RA.

The discipline of engineering is spoken of as a lone field while the researchers divide science into multiple fields. For instance, the British Academic Written English (BAWE) corpus exhibit different branches of science but at university level, it lacks in distinguishing various fields of engineering [12]. The field of engineering is stated as a lone field by Kanoksilapatham, with subfields of biomedical, software and civil [13]. The fields of biochemistry and microbiology are distinguished as distinct fields. In this chapter, the typical specialties belonging to a particular academic field are treated as 'sub fields' within a field. Due to the presumption that the engineering is one gigantic field, the researchers are led to assume that all RA are similar in quality. Maswana et al. has stated that engineering appears to be an undivided field concerned with the production of profitable artifacts obtained by applying scientific principles [14]. However, there is a diversity in the features of engineering RA. They consist of wide range of articles containing mathematical simulations, prototypical experiments, review experiments and observational experiments as revealed from the diverse representation of the results.

3. Restriction of TQM studies to RA

The level of significance of total quality management (TQM) has grown with rapid pace lately. The concept of TQM is seen as a phenomenon essential to attain competitiveness. The researchers correlate the TQM concept with success of an industry [15–17]. Few researchers claim that TQM is just a fad of management by pointing out the failure stories of implementation of TQM [18–20]. There are many inter-related reasons of having different outlooks of TQM. For example, disagreements among founders of TQM, similarities of the concept with other management tools, unclear interpretations and hypothetical definitions of TQM. Therefore, the problems associated to TQM are needed to be addressed. The relevant techniques, tools and values as a wholesome management system are also described.

A. Disagreements among founder

Deming, one of the renowned quality founders, has considered the term TQM to be just a lingo and meaningless word [21]. In [22], William L. et al. stated the concept of quality to be the consequence of a process rather than being a process itself. Juran has been critic of the fact that the term TQM is being tumbling down without defining it properly. The actions included in TQM are actually listed in criteria associated to the reputed Baldrige Award [23]. This reluctance to accept the term TQM seems confusing to the researchers.

B. Unclear interpretations and hypothetical definitions of TQM

The definitions of TQM has been unclear or misinterpreted in literature. The formulations can be seen like "culture of..", "philosophy of..", "approach for..", and "business strategy of.." etc. The respective descriptions of hypothetical definitions is found in literature [24–27]. The definition presented in ISO 8402; 'quality management and assurance' has also been found to be vague [28]. It says, "TQM is centered on quality, and it is a management technique of an organization. It involves participation of all members of organization and aims towards long-run success path through consumer's satisfaction. In this way, it is advantageous to all members as well as to the society." The development and perception of the term TQM over the years from philosophy to culture has been one of the reasons for confusions and the usage of various terms in its definitions. The term philosophy is base of the concept and culture is the required state. This desired state can be attained only when the clear description of philosophy is realized. The explanation of strategy used to realize the philosophy is given in [29]. Another reason of unclear interpretation can be that most of the literature has been penned by consultants and the academia has not been much interested in knowing about what 'TQM' actually is.

C. Similarities of TQM with other management tools

There exists some consensus about what TQM actually means. There has been various similar terms in literature, for instance, total quality control (TQC) [30–31], company-wise quality control [32], total quality improvement [33], and strategic quality improvement [34].

4. Methodology

The articles published from 1 January, 2021 to 31 December, 2021 are studied through cross-sectional survey. The survey comprised of all articles, consisting of self-administered problems, as their dominant methodology and has been published in any of the fifteen journals related to EE, given in **Table 1**.

It is important that the implementation of TQM needs to be peered as a system. The techniques and associated tools support the core values of the articles. The process management technique establishes process orientation. Here, by 'cross sectional survey', it is meant that the data of RA has been collected one time and not repeatedly over a time period. The top publishers are considered for necessary population based categorization. And the satisfaction score (in %), based on the Transparency and Openness Promotion (TOP) guidelines, has been used as the associated statistical technique to present the survey in tabular form as per the quality assessment.

First seven journals were listed as the top EE practice journals, using InCites Journal Citation Report (JCR) published by Clarivate Plc for the year 2021, on the basis of the recent impact factor. Furthermore, the remaining journals are selected based on their representations of significant EE subfields like PD, VLSI etc. and/or organizations like IET, Elsevier etc. The leaflets of each issue of the journal published within this study has been searched manually by two independent investigators for identifying RA satisfying the criteria.

A COMPENDEX search has been conducted to confirm the screening of all relevant RA published in the corresponding journals. The elimination criteria included RA using participant-observation kind interview techniques, market survey, additional qualitative investigation techniques, analysis using combined quantitative/

Acronym	Journal title	Publisher
EC	*Energy Conversion	IEEE
IE	*Industrial Electronics	IEEE
CAD-ICS	*Computer-Aided Design of Integrated Circuits and Systems	IEEE
SG	*Smart Grid	IEEE
MTT	*Microwave Theory and Techniques	IEEE
C	*Communications	IEEE
PA-MI	*Pattern Recognition and Machine Intelligence	IEEE
CC	Computer Communications	Elsevier
ESA	Expert Systems with Applications	Elsevier
PD	*Power Delivery	IEEE
EPSR	Electric Power Systems Research	Elsevier
MAP	IET Microwaves, Antennas and Propagation	IET
VLSI	*Very Large Scale Integration Systems	IEEE
JSSC	*Journal of Solid State Circuits	IEEE
PR	Pattern Recognition	Elsevier

**IEEE Transactions on....*

Table 1.
EE journals and corresponding acronyms used in this study.

qualitative techniques, RA unavailable in complete text or RA in languages other than English.

The evaluation of each RA has been carried out using preceding publication, a checklist tool developed by RA experts. This checklist consists of 8 transportable standards from Transparency and Openness Promotion (TOP) guidelines, that are: (1) data transparency, (2) citation standards, (3) material transparency, (4) analytical approach transparency, (5) analysis plan preregistration, (6) study preregistration, (7) design & analysis transparency and (8) replication. Four investigators participated in an initial test of the prescribed checklist by examining four pre-determined articles that were involved in final survey. The checklist standards were either removed or modified on the basis of consensus. The standards were removed because of the lower chances of its application to EE articles. The standard removed from the checklist was 'study preregistration'. So, the list consisting of remaining standards is referred as the final checklist. Each item in the checklist is weighted as 1 point, as seen in **Table 2**.

Checklist Standards	Description	Satisfaction score, *n* (in %)
1	Data transparency	
	• Background statistical details provided	100 (100%)
	• Sample frame and population of survey provided	90 (90%)
	• Financial inducement provided	28 (28%)
	• Techniques to handle absent data provided	8 (8%)
2	Citation standards	
	• Mode of communication provided	89 (89%)
	• Illustration of who addressed inherent participant	25 (25%)
3	Material transparency	
	• Research tool explained	90 (90%)
	• Pre-testing techniques reported	41 (41%)
	• Psychometric characteristics reported	7 (7%)
4	Analytical approach transparency	
	• Purpose of study is explicitly reported	96 (96%)
5	Analysis plan preregistration	
	• Background particulars reported	100 (100%)
	• Problem formulation provided	45 (45%)
6	Design & analysis transparency	
	• Reliability and validity provided	31 (31%)
	• Objectives are addressed through results	99 (99%)
	• Techniques for data analysis explained	8 (8%)
7	Replication	
	• All responses and respondents are reported	59 (59%)
	• Originality and strengths of research explained	16 (16%)

Table 2.
Satisfaction score of checklist standards in all-inclusive RA (100).

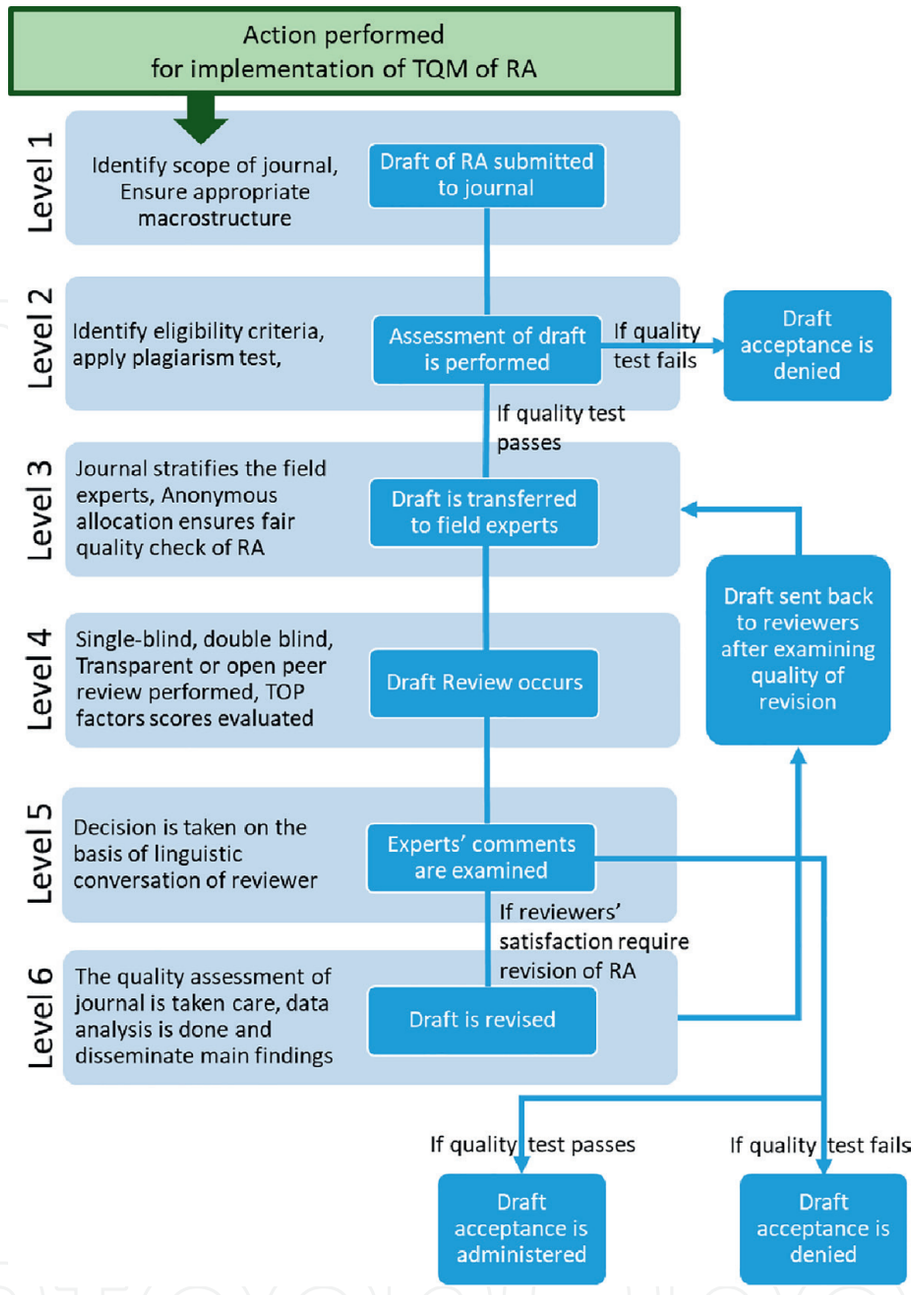

Figure 1.
Implementation of TQM process for quality check of RA.

The following critical collectibles (CCs) has been observed in various articles; research problem, specimen or sample, design technique, control of variables, methodology, analysis process, discussions, ethics and references. The quality management of RA is controlled by a process followed by the corresponding journal. The TQM implementation is directly associated with the concept of the peer review process of a journal, as represented in **Figure 1**. The implementation of TQM for quality check of RA occurs in six levels. Level 1 is administered by the author who is submitting the draft of RA to a journal. The scope of the journal is identified and corresponding macrostructure is followed. Level 2 to Level 5 are administered by the editors/technical editors and field experts of the journal. If quality test of Level 2, that involves eligibility test and plagiarism test, is passed, the field experts are anonymously communicated for examination of the article's quality and possible improvement in the product (RA) (Level 3 to Level 5).

As per the assessment of reviewers' comments, Level 6 of TQM is addressed. If the quality test of article at Level 5 fails, draft acceptance is denied. Otherwise, the quality improvement is carried out ensuring the maintenance of core values of the journal reputation. The dissemination of dominant discoveries is carried out by authors of RA using data analysis tools. Then the process repeats from Level 3 onwards till the final decision of quality test is not communicated.

5. Results

A total of 192 articles were tested for eligibility assessment, out of which 100 articles (52%) utilized quality research as fundamental technique. Out of remaining hundred RA, 62 (62%) used the IMRD format and 38 (38%) used IPTC as the prime representation, including 13 RA from IE, 9 RA from ESA & VLSI each, 11 RA from EPSR, 12 RA from PD, 10 RA from EC, 8 RA from CAD-ICS, 7 RA from MTT, 5 RA from SG & MAP each, 4 RA from JSSC, 3 RA from C, 2 RA from PA-MI and 1 RA from CC & PR each. The primary reasons for exclusion of RA are lack of quality research methodology as the fundamental technique. The critical points denoting the exclusion of RA are represented in **Figure 2**.

The computation of average outline score, out of 7, was performed for RA published in EE literature, by assigning 1 point for each checklist standard. The overall average outline score was 4 ± 2 (2–6). As stated from **Table 2**, the proportion of satisfaction score is obtained by each article as per the checklist standards. The most concurrence areas covered almost 70%, including: statistical details regarding background of research; sample frame & population of survey; mode of communication; research tool; pre-testing techniques; purpose of study; background particulars; formulation of problem; reliability & validity; objectives are addressed through results; reporting of all response and respondents. The RA that reported at the most 30% of checklist standards included: techniques to handle absent data; illustration of who addressed inherent participant; psychometric characteristics; techniques for data analysis; originality and strength of research. The average outline score of journal are

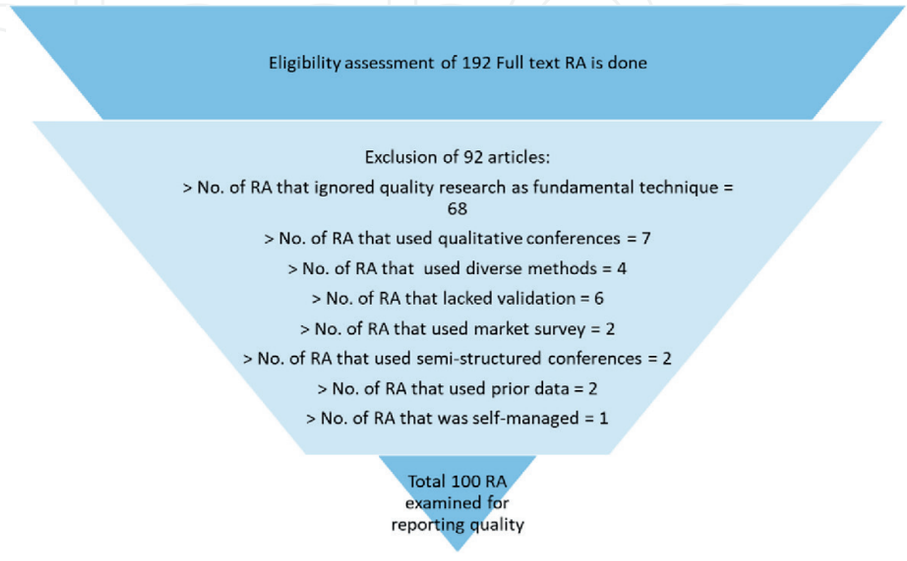

Figure 2.
Screening test and exclusion test of RA.

Journal	Outline score	Journal	Outline score
EC (10)	4.9	ESA (9)	4.2
IE (13)	3.2	PD (12)	3.5
CAD-ICS (8)	5.4	EPSR (11)	2.9
SG (5)	2.8	MAP (5)	2.8
MTT (7)	3.6	VLSI (9)	4.8
C (3)	3.1	JSSC (4)	5.8
PA-MI (2)	4.6	PR (1)	2.7
CC (1)	5.2		

Table 3.
Outline score of EE journal.

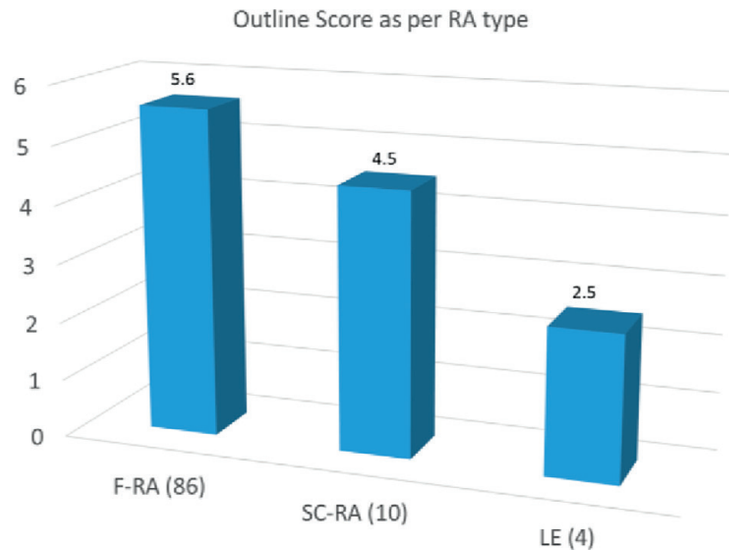

Figure 3.
Score with respect to type of RA publication; F-RA = full research article; SC-RA = short communication research article; LE = letter to editor.

provided in **Table 3**. The highest score has been 5.8 out of 7 for JSSC, 5.4 for CAD-ICS, 5.2 for CC. The outline score with respect to the type of RA is shown in **Figure 3**.

The outline score of 5.6 is obtained by full research article, while short communication type RA had 4.5 and letter to editor had 2.5. **Figure 4** presents the average outline score of RA based on the type of the author. The articles authored by research scholars and graduates of EE has the highest outline score of 5.5 and 4.9 (out of 7) respectively. Whereas EE faculty and Scientists secures almost similar score of ~3.7. the lowest score of 2.7 is obtained by Non-EE category of authors of RA.

6. Discussion on findings and limitations of study

The quality assessment of RA in this chapter established that the research published in leading EE-journals scored reasonably on a recognized platform designed for sequential estimation of quality research outline. The obtained results were

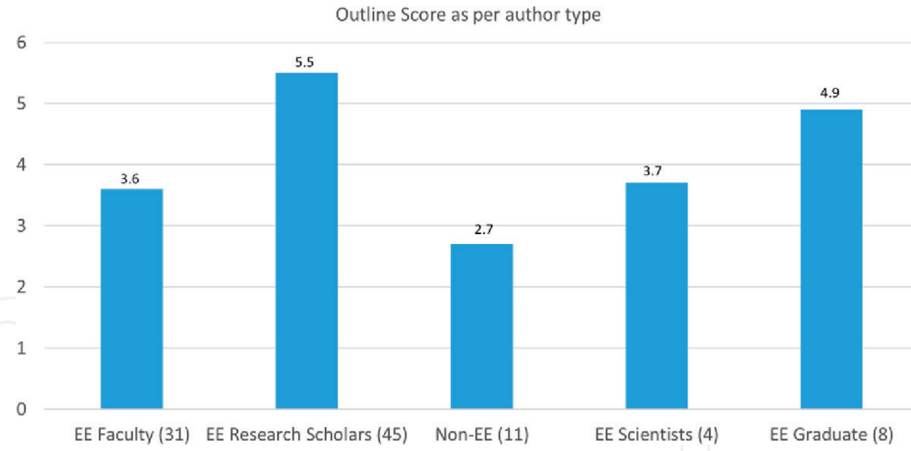

Figure 4.
Score with respect to type of author of corresponding RA.

found to be equivalent across various journals, and author types, when observed excluding the LE type.

This chapter also reveals the different areas that seemed to be associated with lesser scores on recognized platform. On the contrary to the field experts' recommendations, the full problem formulation should not be included in appendix section of RA. Due to this, the reader's satisfaction stage of the TQM gets affected and the end users of the articles become unable to re-use the information about the questionnaire to notify their intrinsic research work. The absence of psychometric properties and validity also arises the credibility or reliability questions of the research work. This chapter recognized certain opportunities for quality improvement with respect to reporting analysis results, that involves risk assessment for undemonstrative error and differentiation between non-responders and responders, and in addition, description of handling absent data and partial reactions.

This study provides the key finding provided the rate of response, on an average, was extremely varying among various EE journals. This may be due to the diverse nature of population which refers to a particular RA in corresponding journal. For instance, an EE research scholar, the most educated population in EC, is more suitable for responding to stimulus as compared to Non-EE population. The areas that report durability included techniques of data analysis, transparency of research limitations, and clarity in report presentation.

This study reflects an equivalent study that was conducted to compute the sample of journals in medical field [35], predominantly for ensuring transparency. This prior study found fundamental areas for possible improvement and reported a recognized platform for former testing and governing reliability and validity. This study provides moderately high performance in former aspect and moderately low performance in latter aspect among EE journals. It is suggested that researchers, who gets engaged in writing RA in EE field for the first time, should cautiously assess Bennett's tool before planning their research study and writing article for publication. This may be advantageous for EE journals to integrate such tools into peer-review instructions to the author, for elevating the quality of RA published in EE journals.

The assessment done by independent investigators for quality management of each RA utilized the standard evaluation platform and systematic techniques for identifying relevant articles. However, there have been certain limitations to our study. For example, with the data collected for only one recent full year, the inclusion

of RA may have missed all RA to different categories of RA. Also, various checklist standards such as identification of who addressed possible field experts, techniques for handling absent data etc. may be of subjective nature. The buildup of score sheets of such standards required the maintenance of consensus between investigators. The opportunity, to inspect for rating the reliability due to going through a vigorous agreement process before going for survey of RA in EE, has been missing. Few article types (like LE), journals (like SG, PR) and types of author (like EE graduates, EE scholars, residents) were not representable. Due to this, the analysis results may not be in generalized form included in the corresponding category. Also, since only first author was categorized, this may represent the absence of the impact of remaining authors' team with respect to the reporting exercise.

7. Conclusion

The RA published in EE literature scored reasonably on a recognized platform consisting of publishing instruments for appraisal of articles in systematic way. The results were found to be homogeneous, in general, across various author types and journal types. The limited form of representation in specific categorization gives rise to limitations to the study. The areas in which the quality of RA can be improved included providing data about psychometric characteristics of existing research tools, validity and reliability of new research tools, possibility for non-responsive errors, differentiation between defendants and non-defendants, and delivering the handling techniques of RA in case the data and responses are missing from RA.

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Conflict of interest

The authors declare no conflict of interest.

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