

A SYSTEMATIC REVIEW OF THE CHALLENGES AND STRATEGIES FOR ADDRESSING PLAGIARISM IN ENGINEERING EDUCATION

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ABSTRACT

Plagiarism is a growing issue in higher education institutions world-wide. If left unchallenged, it represents a threat to genuine academic scholarship and integrity. This paper examines the current state of knowledge based on published research with a specific focus on plagiarism in engineering education. The overall aim of the study is to identify major factors that contribute to plagiaristic behaviour and to develop evidence-based tools, resources and interventions to assist students, faculty and higher education institutions to avoid plagiarism. Furthermore, the study seeks to provide policy recommendations that can be implemented at institutional level. It is found that plagiarism occurs at all levels of academic practice in teaching and research. The reasons why students plagiarise include ease of access to materials on the internet, time constraints, pressures to achieve good grades, lack of academic support and failure to integrate students into the university community. Faculty and universities have a role to play in training students to be ethical users of information. Students should be trained to be able to identify their requirements, to source and paraphrase text, cite references properly and attribute all sources of information. Faculty should also develop authentic instruments of assessments. This will motivate students to develop creative solutions. Plagiarism is however a complex aspect of human behaviour and further research is required to understand it better and to find potential solutions.

Keywords: Academic Integrity; Education; Engineering; Ethics; Plagiarism.

1. INTRODUCTION

Plagiarism is a problem in all higher education institutions and undermines the education process in several ways. It prevents students from developing critical thinking and analytical skills. It undermines the confidence and trust between students and faculty. If plagiarism goes undetected, it impacts on the academic reputation of the institution concerned and devalues its qualifications and awards (Pecorari, 2008). It is therefore important that all academic staff understand the nature of the plagiarism problem and take steps to address it. This paper provides a systematic review of the research literature on plagiarism in engineering education. The study is based on published scholarly sources such as peer-reviewed journal and conference papers. The

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objectives of the study are four-fold: to examine the current state of knowledge on plagiarism in engineering education; to identify the major themes that emerge from the literature; to develop evidence-based tools, resources and interventions to assist students, faculty and members of the higher education community, and finally to provide policy recommendations for implementation at institutional level. The study is timely and extremely important in that for engineering students, academic integrity at university provides the foundational basis for ethical professional engineering practice. Students who engage in unethical behaviour at college or university are likely to continue doing so in the world of work (Eaton, et al, 2021).

A summary of the key research publications reviewed is firstly outlined. Plagiarism is defined and features that characterise it are evaluated. Causes of plagiarism are given. The reasons why students plagiarise are assessed. The features that define plagiarism help to provide the background for understanding the reasons why students plagiarise. Knowledge of the reasons why students plagiarise assists in designing effective policy and student support interventions. Assessment design to avoid plagiarism is discussed. Detection and punishment of students and staff found guilty of plagiarism is a necessary but not sufficient condition for addressing the problem. Students in particular need to be trained to acquire good academic writing skills and appropriate use and attribution of all sources of information used. Other forms of academic misconduct include cheating in examinations or fabricating of written work, research results, sources of information or supporting another student to commit an act of dishonesty, to name a few (Dobrovaska, 2007). These are outside the scope of this paper.

2. RESEARCH METHODOLOGY

The overall aim of the study is to identify the factors that drive student plagiaristic specifically in engineering education. Furthermore, the study aims to develop effective intervention strategies that can be applied to encourage ethical academic practice. This study has been guided by three research questions namely:

1. What factors influence students' plagiaristic behaviour?
2. What steps can university administrators and college deans take to reduce the incidence of plagiarism in engineering programs?
3. How can students be best supported in order to act in an ethical manner and avoid plagiarism?

This paper reports interim findings from the literature review. A systematic review of the literature was undertaken and the work started by identifying rigorous academic literature published in peer-reviewed journal and conference papers, books, theses, dissertations, and academic reports. The literature was identified by searching published sources through electronic search engines including Masader, Google Scholar, Science Direct, and ProQuest. The search terms used to identify the relevant literature were: plagiarism, academic integrity, academic dishonesty, text matching software, Turnitin, and plagiarism detection. These terms were combined with the term engineering or engineering education. The objective of the search was to narrow down and identify those research publications relevant to the engineering education context. Non-academic literature such as university policy documents, social media reports, newspaper articles, unpublished reports were excluded from the study. Other non-scholarly sources of information such as newspapers, blogs, wikis, tweets or social

media outlets were also excluded from the study. Publications on other forms of academic misconduct addressing for example cheating in examinations and contract cheating were also excluded.

3. PRINCIPAL THEMES IN THE LITERATURE

This review is comprehensive but not exhaustive and focussed on the research literature specific to the engineering discipline. Engineering is a very broad subject and differences abound between various branches such as civil, electrical, mechanical environmental, electronic or energy engineering, to name a few. In the study, these disciplinary differences have been ignored and the review seeks to encapsulate all areas of engineering. The main themes to emerge from the review are: plagiarism detection and text-matching software, student and faculty perceptions, prevalence of plagiarism, collusion and cheating, international students, academic integrity generally and potential solutions to the plagiarism problem. Table 1 provides a summary of the key papers reviewed and the principal themes identified from each. The content of each of these publications is discussed in the relevant sections of this paper which follow.

Table 1: Summary of key papers reviewed and their principal themes

Paper	Plagiarism detection	Plagiarism Perceptions	Plagiarism prevalence	Academic integrity	Potential solutions
Barrett and Malcolm (2006)	✓		✓	✓	✓
Bertram Gallant, et al. (2014)			✓		✓
Beute, et al. (2008)	✓	✓			✓
Carpenter, et al. (2010)		✓	✓		
Carpenter, et al. (2006)		✓			✓
Cooper and Bullard (2014)	✓				✓
Duff, et al. (2006)			✓		✓
Eaton, et al. (2020)	✓				✓
Eckel (2010)					✓
Guerrero-Dib, et al. (2020)				✓	
Gunnarsson, et al. (2014)				✓	✓
Henslee, et al. (2015)				✓	✓
Holi Ali (2013)	✓				✓
Kaner and Fiedler (2008)	✓				
Lyon, et al. (2006)	✓				
Mostafa, M (2011)		✓		✓	✓
Parameswaran and Devi (2006)		✓			✓
Pecorari (2003)			✓	✓	✓
Songsriwittaya, et al. (2009)		✓		✓	
Šprajc, et al. (2017)		✓		✓	✓
Srikanth and Asmatulu (2014)				✓	✓
Stappenbelt (2012)		✓		✓	✓
Stappenbelt et al. (2016)			✓		✓
Starovoytova and Namango (2016)		✓		✓	

Paper	Plagiarism detection	Plagiarism Perceptions	Plagiarism prevalence	Academic integrity	Potential solutions
Starovoytova (2017)				✓	✓
Starovoytova and Namango (2017)		✓			✓
Vesilind (1996)		✓		✓	
Vieyra, et al. (2013)	✓		✓		✓
Wan, et al. (2011)		✓			✓
Whittle and Murdoch-Eaton (2008)					
Yeo (2007)		✓		✓	✓
Youmans (2011)	✓				✓
Zhang, et al. (2014)	✓				✓
Zigmond and Fischer (2002)		✓		✓	

4. CHARACTERISTICS OF PLAGIARISM

Plagiarism is the practice of taking text, work or ideas of someone and presenting them as your own without acknowledging the source. Text in this context includes sets of equations, words, program codes, photographs, to name a few. Plagiarism is a form of deception or cheating. Sutherland-Smith (2008) presents a six-element definitional model of plagiarism. The key elements are that an object which may include language, words or text is taken from a particular source by a student, academic or other person without adequate acknowledgement and with or without intent to deceive. In computer programming for example, source-code plagiarism is defined as the reproduction and copying of code without making any major changes or adaptations (Pawelczak, 2018). Plagiarism constitutes academic dishonesty. It is for this reason plagiarism is treated very seriously in colleges and universities.

Plagiarism occurs at all academic levels. It includes both undergraduate and postgraduate levels. Bretag (2013) reports results of a survey at Australian Universities, which found that one in five postgraduate research students had never heard of academic integrity and two in five postgraduate students did not know whether their university had an academic integrity policy or not. Some established researchers are involved in questionable academic practices too. Bretag (2013) reports results of a survey in the United States of America that found that one-third of respondents had engaged in questionable research practices. The Committee on Publications Ethics (COPE) discusses thirty to forty alleged cases of research plagiarism over a ten-year period. Established researchers have also been found to engage in self-plagiarism where they duplicate substantial parts of their already published work without sufficient acknowledgement (Cross, 2007).

The four attributes that are necessary to identify plagiarism include the following. Firstly, there must be similarity between the texts. Secondly, production of the second text must have been based on the earlier text. Thirdly, there must be an inter-textual relationship. That is, the text must be similar enough to suggest a causal relationship although similarity on its own alone is not sufficient proof that there is plagiarism. All materials that were referred to in the production of a piece of academic writing must be correctly acknowledged. If not, that may constitute plagiarism. Finally, there must be intent to deceive on the part of the plagiarist. Many policies in colleges and universities

do not take intent to be relevant. In any case, proving intent can be difficult because it is only the culprit who knows whether they intended to plagiarise or not. Isoc (2014) argues that there is no such thing as unintentional plagiarism and that unintentional plagiarism is a hypothetical concept.

Dobrovska (2007) compares and contrasts cheating, plagiarism and collusion. She asserts that cheating is an intentional act of dishonesty. However, plagiarism can be committed intentionally or unintentionally. Furthermore, collusion is an act of dishonesty that is undertaken in co-operation and collaboration with others. However, what constitutes plagiarism is not so clear-cut for students particularly in their early years of higher education (Stappenbelt & Rowles, 2010; Stappenbelt, 2012). Skill deficiencies and language barriers are the two main factors that may explain the incidence of plagiarism where it occurs particularly for international students. Fortunately, both international and domestic students possess the abilities to recognise plagiarism and to take steps to correct it (Duff et al., 2006). Yeo (2007) concludes that although students can provide sound theoretical definitions of plagiarism, they do not always appreciate the scope of activities that constitute plagiarism.

5. INCIDENCE OF PLAGIARISM IN HIGHER EDUCATION

Almost all universities have policies in place to address the issue and they take their responsibilities very seriously. The Quality Assurance Agency (QAA) in the United Kingdom report that 50,000 students over a three-year period were caught cheating. This equates to about 17,000 students per year or 0.7% of students every year (QAA, 2020). The vast majority of universities have sound policies in place and use of text-matching software for plagiarism detection. These numbers show that plagiarism is not an isolated event. If it were, then it could be addressed through detection and punishment. Plagiarism is actually much more widespread although the exact extent remains uncertain.

Eaton et al. (2021) find that plagiarism is widespread amongst students and academic staff in engineering, as in other fields but policies and their implementation are often inconsistent. Universities therefore need to provide clearer guidelines and greater support for students and academic staff. Mostafa (2011) argues that creative disciplines such as architecture require discipline specific approaches to address plagiarism in education and this should assist in promoting ethical behaviour in their later years when in professional practice. Carpenter et al. (2010) found that engineering students self-reported higher rates of academically dishonest behaviours compared to their peers in other programs of study. This is not because of their innate characters but probably due to the contributory factors of the nature of the curriculum and course design. Plagiarism rates may be higher in technical disciplines precisely because reports and essays may not be the predominant form of assessment (Barrett & Malcolm, 2006).

There is concern that many students may submit assignments written by essay mills where the work is obtained through contract cheating. Text-matching software and tools such as Turnitin, Unicheck or Crosscheck cannot detect this. Detecting this kind of paid impersonation is nearly impossible. Techniques such as stylometry used by historians investigating authorship of historical documents can assist (Cross, 2007). However, systems to identify academic misconduct of this nature are yet to be developed. There is need for research to ascertain the extent to which plagiarism and contract cheating may

be prevalent in higher education institutions internationally. There is also need to evaluate the extent to which there may be concerns regarding contract cheating and plagiarism among students, academics, employers and members of the general public regarding the risks posed by plagiarism and contract cheating. Best practice in detecting and addressing contract cheating and plagiarism should be identified and disseminated.

6. REASONS WHY STUDENTS PLAGIARISE

In order to prevent the reoccurrence of plagiarism in an institution and to develop an ethical academic culture, it is essential to understand student attitudes to plagiarism in the first instance (Stappenbelt, 2016). If students are warned that they should not plagiarise and if they know that the consequences of cheating when caught will be severe, it would be expected that this would make students less likely to plagiarise. However, if the students perceive that the chances of not being caught are high, then they are likely to plagiarise. Students plagiarise because they have ease of access to materials on the internet and new technologies which make it easy to copy materials. As to whether male students are much more likely to plagiarise than female students, results of research into this question are mixed.

Time constraints are also likely to be a contributory factor. The lack of time, inability to cope with the workload, lack of knowledge regarding how to cite sources, how to find materials and how to research or ability to express ideas are all possible reasons for why students plagiarise (Šprajc et al., 2107). Time constraints may arise because students have part-time jobs or have been given unrealistic deadlines. Extremely challenging assessments may also drive students to work together which inadvertently leads to collusion.

The pressure to achieve excellent grades is also a factor. An excellent student keen on getting a good grade but faced with a particularly difficult assignment may be tempted to plagiarise. However, it should be noted that there is an inverse correlation between student plagiarism patterns and examination grades. Cheating leads to higher failure rates, lower scores in examinations and raises the possibility of dropping out of a program (Pawelczak, 2018).

Students who are loners and do not feel particularly integrated as part of the University community are more likely to plagiarise. Finally, strong peer disapproval of plagiarism means that students are less likely to plagiarise. However, students who are in a group where others are plagiarising are much more likely to follow suite (Pecorari, 2003).

Prior warning of students about plagiarism checks does not necessarily reduce incidence of plagiarism (Youman, 2011). The amount of plagiarism that instructors can expect may depend on the type of assignment that students are required to complete. Dense scientific work may be difficult for students or even experienced researchers to summarise. Plagiarism detection software is not a silver bullet for elimination of plagiarism but it is a helpful tool for identifying sources of plagiarism. Plagiarism is a complex human behaviour that requires further studies to understand and address. Plagiarism if left unchallenged represents a threat to genuine and authentic scholarship.

Plagiarism is caused by a novice approach to information (Keilson & Cooperstein, 2007). Thus, academic staff have a responsibility to teach students competencies of information literacy. Students should be taught the skills to define their information needs, locate relevant information, access it, evaluate it, analyse it and use it ethically.

Librarians can also support students to develop these skills including academic writing (Eckel, 2010). In addition, other departments in universities can be useful in supporting students to develop academic writing skills. These include academic advisors, academic writing and student support centres.

7. ROLE OF ACADEMIC STAFF IN ADDRESSING PLAGIARISM

At the heart of addressing plagiarism are individual academic staff. A questionnaire survey of fifteen academic staff in an engineering school conducted by Starovoytova and Namango (2017) concluded that there was a lack of understanding among faculty about the basic elements of scientific writing which leads to plagiarism. The study also revealed lack of relevant policies to detect and punish plagiarism at that particular institution. Clearly, the sample size for this study was very small and the results cannot be generalised (Starovoytova & Namango, 2017). However, this calls for further studies on plagiarism on a larger scale and in-depth analysis. Behaviour, attitudes and values acquired by students during their formative years at university provide the foundational basis for their careers and professional practice. Of relevance to this are behaviours related to academic integrity and plagiarism.

A small-scale study based on a survey of twenty-five engineering students revealed that overall, there is widespread deficiency in students' understanding of plagiarism and what constitutes good academic writing. Engineering students should therefore be trained in areas such as information gathering, research techniques, analytical and referencing techniques as part of their undergraduate curriculum (Starovoytova & Namango, 2016). Whilst the results from this study cannot be generalised because it is based on a relatively small sample of students in one engineering school, it reveals that further research is required. The results are also based on self-reports from students. Detailed research is required to uncover the root causes of plagiarism behaviour by students and to develop effective intervention strategies (Starovoytova, 2017).

Detection of plagiarism where it occurs is the responsibility of academic staff. It is advisable for recently appointed academic staff to consult with their peers or Heads of Departments before pursuing a case of plagiarism against a student. Norms in a program, college or university influence student actions and behaviour (Bertram-Gallant, et al, (2014). If students notice that an institution has lapsed systems and academic misconduct is not detected, they are more likely to continue engaging in such unacceptable behaviour. Zigmond and Fischer (2002) argue that even small transgressions of academic misconduct should not be condoned. Tacit acceptance of these little unacceptable behaviours may in due course lead to serious unethical behaviours.

Academic staff have a role to play in promoting academic integrity by designing academic assessments that require original solutions. One approach to tackling plagiarism in higher education is to rethink academic assessments. Students can generally be assessed using a range of assessment methods (Race, 2014). Whatever the chosen method of assessment, all academics and their institutions would like to be confident that the work submitted is that of the student. Therefore, at one extreme end of the assessment spectrum would be to increase the proportion of marks allocated to supervised final examinations. The main limitations of examinations are that they are

not a good indicator of the breadth of skills and intellectual abilities that employers require.

Academic staff, colleges and universities should consider developing authentic assessments. Authentic assessments seek to replicate the sorts of problems that graduates encounter in the world of work (Barrett & Malcolm, 2006). Authentic assessments provide opportunities for students to demonstrate a whole range of transferable skills including critical thinking, problem solving, team working and communication. For example, project-based activities make it harder for students to plagiarise work from outside sources. Students can still copy solutions developed by others within the same class but this is easier to detect, for small class sizes but not large cohorts. Plagiarism detection tools are available to detect levels of similarity and therefore likely collusion between students (Adeva et al., 2006).

Training of students to avoid plagiarism can take many forms. Online tutorials are as effective as pre-recorded lectures in addressing students' skills deficiencies to tackle plagiarism (Henslee et al, 2015). Further work is however required on this to compare and contrast the effectiveness of two teaching strategies namely: online tutorials and pre-recorded lectures as opposed to taking no intervention at all. Whatever form it takes, instructional support and engagement with students is a very promising approach to reducing plagiarism (Duff et al., 2006).

8. ROLE OF THE HIGHER EDUCATIONS INSTITUTIONS

Most, if not all, colleges and universities take plagiarism very seriously. The first role of the Higher Education Institution in this area is to define and disseminate to students and staff an appropriate policy and regulations which govern plagiarism and all other forms of academic misconduct. Most policies will define and explain what plagiarism is and the procedures that should be invoked by academic staff where plagiarism is suspected. Policies should be clear and specific enough so that all stakeholders know how to apply them in practice. A policy that is ambiguous is likely to lead to staff difficulties in implementation. Detection of plagiarism is important. Students in particular should be aware and know that any plagiarism or attempts to plagiarise are likely to be detected and punished. Staff will require professional training and development in this regard.

Text-matching software provides detailed and rich feedback to students and staff alike, thus helping them to improve quality of their academic writing to avoid plagiarism. They save time and also provide a quantitative measure of the percentage of text matching other publicly available online sources. However, these reports have limitations. One of them is that many engineering publications particularly old ones are not part of text-matching databases and therefore cannot be detected. Secondly, students can play with software settings in an attempt to falsify output reports from the text-matching software.

An increase in plagiarism cases in an institution may signal that its students are cheats. A decrease may indicate that faculty at the higher education institution do not take plagiarism seriously. It is essential that the institution collects annual statistics on incidences of plagiarism and benchmarks this data with other similar educational institutions of its size. This will enable the institution to be able to evaluate the effectiveness of its anti-plagiarism measures.

Concerns have been expressed regarding the interpretation of text-matching software reports. Student concerns include use of unavoidable technical terminology and phrases which are highlighted by the software as plagiarised text (Whittle & Murdoch-Eaton, 2008). A percentage figure copied in a report that is deemed acceptable or the declared cut-off point by the institution also requires interpretation. Text-matching software should be perceived by students as learning aids and not as tools for detecting poor academic practice. Text-matching software is not a substitute for supporting students and teaching them to develop good academic writing skills. This is the responsibility of all academic staff.

It should also be noted that text-matching software detects textural similarities, but may not detect non-textural elements such as graphs and figures which tend to be common in engineering publications (Zhang et al, (2014). Furthermore, text matching software cannot detect some forms of plagiarism such as undocumented ideas and collusion. This occurs for example in situations where students are given an individual assignment but students then choose to share solutions to the assignments. This is relevant in engineering where students are usually given tasks to design systems, solve technical problems, write reports or develop computer codes, etc. Techniques for detection and prevention of this type of plagiarism include for example giving each student a unique assignment and requiring individual presentations of the assignment findings, (Halak & El-Hajjar, 2016).

Other plagiarism detection software includes FreeStyler which detects uncharacteristic changes in writing style in a document. This can be used to show if paragraphs or sections of a document have been lifted from a different source. Stylometric programs can assess a range of factors such as spelling conventions, punctuations and where these changes simultaneously give a reasonable indicator that such material has been copied from somewhere (Cross, 2007). Plagiarism detection also has some limitations in the context of a learning environment. For example, students may also be forced in some instances to obfuscate solutions so as to bypass plagiarism detection (Pawelczak, 2018). Plagiarism detection has however advanced to a point that it can be applied in other languages such as Chinese and programming codes too (Lyon, Barrett, & Malcolm, 2006).

Plagiarism should be approached as an educational matter and not as a punitive one (Gunnarsson et al., 2014). All students at both undergraduate and postgraduate levels need the education on how to paraphrase text, cite and reference properly. International students have not been found to plagiarise more than domestic students particular when they have been trained to understand what constitutes plagiarism (Smith et al., 2016). Students need to be trained to become better and ethical consumers of information. Students need to be trained to be able to locate what they need. To enable engineering colleges to do so effectively requires a deeper understanding of how practicing engineers research for information and to develop strategies and approaches to ensure that these methods are addressed effectively in the engineering curriculum. Surveys of practicing engineers, faculty and students would shed more light on these training needs.

9. THE WAY FORWARD

This study was limited to a literature review, where it suggests broader and in-depth investigation in to the study area. Hence, using both qualitative and quantitative research techniques, the next stage of the study will involve collection and analysis of primary data. Data will be collected using telephone interviews, focus groups and self-completion questionnaires. Online and digital technologies will be used to collect survey data and focus groups will be conducted via online team meetings. Survey respondents and membership of focus groups will include university administrators, engineering faculty and students. The survey will be extended to cover universities from different countries to enable comparative analysis. Factor analysis will be undertaken with tests such as the Kaiser-Meyer-Olkin measures and the Bartlett's test of sphericity being applied to ascertain the robustness and suitability of the data. Other techniques that will be employed include logistic regression and structural equation modelling. Descriptive and inferential statistics will be used including the chi-squared and F-tests. Computer packages such as MINITAB and SPSS will be used to aid analysis of quantitative data.

10. CONCLUSIONS

Plagiarism continues to be of increasing concern in higher education institutions world-wide. In many institutions, text-matching software such as Turnitin or Uni-check are integrated with Learning Management Systems such as Moodle or Blackboard. This enables work submitted by students to be checked automatically for plagiarism. Such software should be seen as a tool only to help students to improve their academic writing practice. Turnitin or Uni-check per se cannot detect poor academic writing practice. Use of Turnitin should be seen as part of a major cultural change required in institutions. It is essential that every institution develops a culture of ethical behaviour where students receive appropriate support to develop time management, critical thinking, communication and academic writing skills. Time management will enable students to submit assignments on time and reduce stress, which has been found to be one of the key causes of plagiarism.

Plagiarism should be taught in engineering schools in the context of work ethics and educational culture. All students irrespective of their background have the potential to address plagiarism issues. Addressing plagiarism effectively will require academic staff to be more innovative and to review their assessment strategies in order to test the students' learning outcomes. Academic staff will need to develop creative approaches in assessing students' knowledge. By modifying and individualising their assignments and tests and developing authentic assessments, students will be forced to develop creative solutions to assignments and this will make it harder for them plagiarise. Ethics is central in engineering education. Academic staff must do everything possible to detect and deter cheating of all forms and to prevent it from happening in the first instance. Instructor inaction constitutes complicity with cheating practices and this is entirely unacceptable. Fortunately, student support, engagement and training in academic writing skills represents the most effective approach to addressing the plagiarism problem in engineering education. Finally, although the exact extent of plagiarism in Higher Education Institutions is unknown, there is need for research to collect empirical evidence on its prevalence and to develop best practice guidance for addressing all forms of plagiarism including contract cheating in engineering education.

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