

Ethical Concerns in Engineering Publications

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Abstract

Most academic tangible rewards are based on a faculty member's or researcher's publication record. The resulting increasing pressure to produce publications earlier and more often in the academic's career exacerbates the problem of a lack of clarity in ethical standards for multi-authored publications. The timing and frequency standards associated with publications for tenure and promotion and continuing research funding opportunities result in academics' maximization of the number of research efforts taken to publication with the number of authors per scientific publication steadily increasing. Further, as the number of authors has increased, the level of contribution of each co-author to the research project and publication decreases. This paper: (1) explores the ethical issues related to publication, authorship, and mentoring with the goal of better defining co-authorship standards as well as encouraging research ethics discussion and education, and (2) examines the current factors affecting the academic research environment and describes some of the unspoken but ethically questionable practices in the academic community.

Keywords: *Ethics, Education, Integrity, Authorship, Mentoring, Publications, Research, Research Misconduct, Responsible Conduct of Research, and Scientific Integrity.*

Introduction

The problem of ethics, authorship, and dishonesty in engineering publications includes fabricated data, misleading conclusions, or false reviews [1]. Though the referenced examples do not address the extent of the co-author contributions or how this authorship status might have been falsely earned in first place, they still give a sign of a growing and alerting problem that touches upon the integrity of the civil engineering academic community. Thus, the importance of the researcher's individual contributions in peer-reviewed publications and the researcher's own impact on the research and professional communities could be measured using: (1) the weighted number of journal papers published per year where the weight of each contribution is the inverse of author number, and (2) the weighted number of citations per year where the weight of each article citation is inversely proportional to the number of co-writers of the paper that is cited [2]. Similarly, another approach was highlighted for evaluating individual author's contribution in a multi-authored article using a numerical score with a mathematical formula of $[1/n + 1/m]$, where n = rank order of the author, m = total number of authors, and the total credit associated with a manuscript is the sum total of all individual authors' score that is then equally divided amongst the authors [3].

Until the 1950s, the majority of publications were developed by a single author [2]. Since 1955, the norm in authorship has shifted from the 1-2-author publication to the 3-4 author publication. There is a distinct increase from an average of 2 authors per paper to an average of 3 authors per paper over a period of 10 years in the area of requirements and software engineering. This increase in multiple authorship works and number of authors could be attributed to the growing pressure for funding, promotion, and tenure in U.S. universities as well as the interdependent increased need for collaboration [1, 3, 4, 5, 6].

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Ironically, during the 1980s, 20 researchers (10 of whom were heads of biomedical labs) published articles once every 11.3 days [7]. One author in the study was a co-author on 948 papers between 1981 and 1990, which is a publication rate of one paper every 3.9 days [8]. Today's research efforts involve many collaborators and those collaborators may not have a complete or even any understanding of their collaborators' work or the research problem the other collaborators are addressing. A single co-author may have no knowledge of the full scope of a project other than the knowledge gained by reading the final draft of the manuscript [10]. Reliance on previous research is a matter of trust in the researchers' ethics with regard to methodology, results, and the ability of authors to answer questions pertaining to their work. In the cases of multiple co-authorship, if the assumptions about reliance on co-authors' abilities is incorrect, the processes of peer review are flawed in that the identity of those who can provide explanations and verifications for the underlying research is unclear or misleading.

Research Objectives and Methodology

Graduate students, junior and tenured faculty, technicians and administrators, and field practitioners in the civil engineering community need to develop a framework for understanding research ethics in relation to publication, authorship, and mentoring. This paper utilizes an interdependent four-step methodology to attain the aforementioned objectives. First, the authors present a historical overview of the evolution of ethical standards in academic research and publication. Second, the authors demonstrate how the increasing pressures within the academic environment pressures impacted co-authorship status. Third, the authors explore the evolving different types of co-authorship relationships and their possible effects on the research community. Fourth, the authors analyze the ethical issues governing status of authorship.

Historical Ethical Standards in Academic Research and Publication

In 2007, the Office of Research Integrity (ORI) and European Science Foundation (ESF) held a conference for the purpose of addressing research integrity through attempts to create and develop international standards for ethical issues in research conduct and publication [11]. In fact, international standards for the ethical conduct of research for human subjects have existed since the Nuremberg Code adopted at the end of World War II [12]. With the timing and recognition issues somewhat resolved and the publication of those results defining ownership of the discovery, a resulting issue was the question of who should be included as an author for soon-to-be-published works. The historical overview presented by Whitbeck [13] provides two crucial questions in determining authorship, namely: (1) who warrants inclusion as an author for an article, and (2) the order in which the authors are listed. For centuries, the determination of authorship was a fairly simple process, because of the limited number of authors. However, the discussions surrounding co-authorship were not as complex because of the limited number of co-author situations as well as the absence of the role of contributors; individuals who are involved at various stages during the researcher but who may not contribute to the drafting of a published report [2]. The confusion regarding co-authorship status and contributors and disclosures about both has arisen because of the nature of academic research. Certain drivers and structures add complexities to the determination of co-author status and serve to muddle what were once accepted norms. Those drivers and structures are discussed in the following section.

THE ACADEMIC RESEARCH ENVIRONMENT

Various studies have compiled lists of the influences and trends that increase, facilitate, or cause shifting norms in co-authorship status forms in academic research activities. These influences can be grouped into three categories: collaboration, funding, and measures of academic performance. These trends have resulted in the increase of multi-authored publications as well as differing and confusing ethical norms on defining co-authorship status in the academic environment.

Research Collaboration

Academic research no longer a solitary or even dual activity but, rather, is now a collaborative effort that brings together academic units such as different departments in a university, researchers from different colleges and universities, with both of these forms of collaboration conducted across continents. As a result of extensive collaborative efforts that are not always well defined at the beginning of the relationship, there is often confusion about responsibility, accountability, and recognition for the research results. Other issues that emerge in these collaborative efforts across universities are the complexities of funding, reimbursement, and allocation.

Research Funding Sources

The nature and sources of research funding have added additional parties to the collaborative research effort. There is a partnership trend of businesses and industry working together in research collaboration; that is these joint efforts of business and academia result in both similar and different ethical issues as those that arise in academic collaboration. These educational/business joint ventures generally mean that business and/or industry are funding the research efforts. Such financial support raises not only questions about authorship, accountability, and responsibility, but also involves issues such as conflicts of interests and the when's, how's, and extent of disclosure of those funding sources for the project. As a result, questions about co-authorship arise when those funding the research realize that the findings may be detrimental to the funding company or its industry. For example, Merck prohibited its scientists who had worked jointly with academic researchers from allowing their names to appear on the publication of the joint research results because those results indicated that Merck's drug Vioxx resulted in cardiovascular effects in certain patients. Co-authorship was withdrawn from the published results [14]. In this situation, the non-disclosure of all the researchers was relevant to the evaluation of the research. Despite funding disclosure, the withdrawal of a researcher's name is left to the funding company and that withdrawal is relevant but undisclosed information about the quality of the findings in the results. The withdrawal also deprives the scientific community of a resource for information on the underlying research. The goals of profit and competitiveness are not in line with conduct/release of research [10].

Tenure, Promotion, and Performance Reviews

An academic's publication record is the basis for the tangible rewards of academic life such as tenure and promotion, contracts and grants, honors, salary, including merit pay, status, market competitiveness, and prestige. The pressure to produce publication/research results comes from the consequences of no results, the inability to obtain new funding and/or the denial of tenure, promotions, or merit increases in salary. The individual pressure is exacerbated by general professional conditions. In 1973, 40,600 individuals held PhDs, That number more than doubled, to 93,000 by 1997. In addition, the number of outlets available for publication (some of which may be the same article for co-authors in different fields) increased from 174,368 in 1966 to 529,983 in 2002 [15]. Performance metrics for academics are quantitative with assumptions made about the quality of the peer review based on journal ranking processes. This system of counting serves as a dashboard measure reduced to the simple formula of: the greater the number of publications; the more grant funding and the greater the grant funding; the greater the number of publications. The impact of these facile measurements of research contributions is a sort of careerism when research turns from avocation or hobby to a form of artificial counting where scholarship may fall short of the standard of meaningful contribution to the field but does qualify for the measures used for career advancement. The attainment of publication or funding has been compared to an academic obtaining a coin that entitles them to admission to the next event or level and the chance to earn more coins [16]. The coins have different values according to the level of achievement, i.e., a publication in a Tier-1 journal is a coin of greater worth than a Tier-3 journal and an NSF grant is worth more than private foundation funding. While there are some software programs such as "Publish or Perish" and "Google Scholar" that purport to offer formulas for checking co-author contributions, each of these systems comes with a caveat emptor for those who are reviewing the record of an individual researcher to do their own reviews and inquiries about the level of work and contribution on a published paper.

TYPES OF MULTIPLE-AUTHORED RELATIONSHIPS

Work to date has established types of co-author relationships that range from the classic example of partners in research such as Watson and Crick to department heads adding their name to all works that originate in their departments.

The Gift or Honorary Authorship

In this type of arrangement, those authors who have done the actual design, conduct, and writing of the research decide to bestow co-author status on someone who has had little or no affiliation with the project [8]. This is a form of honorary authorship that those who bestow do not find ethically troublesome because it is their decision to do so. However, in cases of discovery of honorary authorship there has been too often research misconduct as well such as in the fabrication of data [17]. Even without the fabrication of data, placing the name of a friend on a publication with the goal of expanding the vitae has been called a "deplorable practice bordering on research misconduct" [18].

The Career-Boost Authorship

This form of co-authorship is given by the principal author to the PhD student or the junior faculty member as a means of boosting their chances for being hired or attaining tenure or promotion. For the principal author there is little downside to such beneficence but there is the upside of gaining high placement of the PhD student at a top institution and the additional credibility obtained from being part of a uniformly prolific department. This form of co-authorship has been referred to as a “dubious practice” that is likely to backfire [8].

The Career-Preservation Authorship

This form of co-authorship is given to a department chair, a dean, a provost, or some other administrator in the academic unit or institution because of the express demands made by that administrator as well as those made implicitly because of the control they may exercise over the author’s schedule, summer grants, promotion, tenure, or merit increases. For the administrator, the benefit is one of being able to document research productivity that provides flexibility and mobility in the event of a career change or recruitment by another institution. For the principal author, the benefit is good relations with those who exercise control over his or her career. This form of co-authorship has been called an unethical practice that borders on fraud [19].

The Ghost Co-Author

This form of co-authorship can take two forms. The first is a non-disclosure form of co-authorship. That is, the identity of an academic who has indeed contributed to the work is not included in authorship because of that author’s conflicts. Jones documents the case of W.S. Gosset who published his works under a pseudonym because he was employed at the Dublin beer producer, Arthur Guinness & Sons, a company that had a policy prohibiting employees from publishing their research after a previous employee had revealed proprietary information about Guinness research, development, and production methods through published works. Gosset published his work as “Student” and did not want to disclose his ties with the Guinness Company [8]. The second form of ghost authorship involves those in industry doing the research, compiling the literature, and writing the results and then asking an academic to review the article and underlying research and then agree to put his or her name on the work. The academic is, obviously, paid for the review as well as for allowing his or her name to be used. Either form of ghost authorship results in a non-disclosed conflict of interest, the withholding of a type of information that editors require to be disclosed prior to publication. This form of co-authorship has become so common that the top ten medical schools have been asked by congress to provide information on their policies for faculty members about ghost writing [20]. Senator Charles Grassley has described the practice as a form of plagiarism and is misleading in that doctors, in reliance on the published article with a prestigious author, might prescribe treatments that could be less effective than others than were not tested by the industry scientists who obtained the academic’s imprimatur on their work [20]. The ethical issue in ghost authorship is the non-disclosure of a conflict of interest, or the failure to disclose all those who are involved in the research so that it can be evaluated not only on the basis of the findings but whether, when there are issues regarding those findings, whether there was influence from the conflicts. That evaluation cannot be objective if the funding sources are not disclosed fully. Both authorship and sponsorship remain critical elements in the evaluation of the validity of the findings of research.

The Confusing Collaborative Co-Author

Some funding proposals emphasize collaborative activities between faculty members from different disciplines or universities. This collaboration strengthens scientific innovation and creativity across the academic community especially if the research is initiated by a junior researcher and the collaborating member is a senior faculty member who is invited to provide insight and guidance based on his or her expertise. However, in other cases, this collaboration is not true and is more of a joint venture that is based merely on mutual interests between a mentoring senior faculty member and a mentee junior faculty member. This type of superficial collaboration crystallizes when the published work, written by one of the collaborators, shows very little relation to the initially proposed work. Unfortunately, these ethically questionable collaboration arrangements find fertile grounds within NSF research grants because the collaborators misuse the scientific freedom given by NSF to modify and amend the research approach as appropriate through discussion with the associated program director. In these forms of confusing collaboration, the end result is not the dynamism of interaction that those who fund the research sought. Rather, the collaboration is used merely as a means of funding for a junior collaborator which ultimately puts other researchers at a disadvantage. While there have been changes in government funding rules across universities, with the presence of co-authors reducing the percentage of funding each institution receives, those funding rules will serve to modify co-authorship norms only as it relates to funded research, not with regard to published results from unfunded

research or privately-funded projects. Further, performance review standards may not have shifted to acknowledge funding allocations and simply rely on the metric of number of grants as the measurement.

The Editor Co-Author

In this type of co-author relationship, faculty members, especially those in the same department; list each other on their papers without any true collaboration on design, hypotheses or findings. Their contribution is that of reading the manuscript and offering editorial or graphical remarks, if any. Their position as co-author is misleading in the sense that they have offered their imprimatur to the underlying work without having participated in it and without truly reviewing the results for their accuracy, importance, or consistency with the design and methodology. These editor- co-author relationships are triggered by the pressure for tenure that tends to result in the formation of social networks within departments that are based on interpersonal favors. The distinction between this form of co-authorship and the gift co-authorship is that there is some connection with, at a minimum, the manuscript or paper, pre-publication.

The Unrecognized Co-Author

Some faculty members, in the interest of acquiring a sole-authored or limited author piece rely on other faculty for assistance in their research. These faculty members have truly contributed to problem definition, methodology, testing, or analysis. This effort is recognized in the work only by an acknowledgment at the end of the manuscript for their assistance. This practice of keeping authorship to a minimum is meant to stop authorship from being diluted among various, yet deserving, authors. This unfortunate arrangement is usually triggered by a junior faculty member who seeks the assistance of a senior faculty member outside his research area and who at this stage of his/her career might not focus much on adding a new paper to his already rich portfolio, and just be pleased with an acknowledgment. This approach is, at a minimum, misrepresentation about the abilities of the authors who are listed. The ethical compromise relates to the assumed accountability of the author, but that listed author who has relied on others may not be able to provide the responses and implications to other researchers that authorship claims connote. Their work is not truly their own but has had the benefit of guidance from other scholars who were necessary for the formulation and completion of the project and the analysis of results.

The Cartel Co-Authorship

This form of co-authorship consists of a group of 3 to 5 senior academics who systematically co-author together, but they proceed in a rotational manner with each work led by one researcher at the time. This form of "research friendship" boosts the publication record for all members of the group. The ethical concern is the assumed knowledge level of the members of the group with all facets of the project when, in reality, each is proceeding with one project with full attention, as other group members do the same with limited knowledge levels about each other's work, methodology, or conclusions.

The Long-Suffering and Unrecognized Graduate Assistant Co-Author

In working in their mentor relationships with graduate students, some faculty members do not frame a research problem for their students but, rather, tend to assign them a general topic (XYZ) to work on during their studies. This broad direction is an effective means for fostering graduate students' independence, innovation, and creativity, which are needed skills for both their educational experience and development and their future careers as academics. However, in some cases, the students are instructed, under the guise of getting experience, to write research proposals including the literature review, problem definition, objectives, methodology, and often even intellectual merit and broader impacts. The limited work of the mentor or major professor is one of revising, minor editing, and submitting. However, the submission is done in the mentor's name coming first as a principal investigator and the graduate student listed at the end even after other co-principal investigators that the mentor decide on and who might fall in any of the aforementioned types of authorships. Such a submission, again, misleads those who are reviewing the proposal because the principal investigator's work is not present in that proposal – the work, understanding, and conceptual grasp of the project lie with the graduate student. Graduate assistantships were created with the idea of dual benefit. The professor/mentor has ideas exposed and implemented and the student is provided an opportunity to earn both experience and a doctorate or masters degree. The intent of an assistantship was not to have graduate students undertake the work of the mentor, work which is then ultimately used for promotion and tenure. Further, in the context of co-authorship, the work is presented to the editors and public as that of the professor/mentor without the disclosure of the deft hand, insights, or abilities, or lack thereof, of the graduate student.

The same type of co-authorship issues arise in journal publications through various possible scenarios. In some cases, mentors provide little or no guidance to their graduate students and use them to write papers during the course of their study that are then published after their graduation with little or no acknowledgment of the student's work on that paper. In other cases, the graduate students are instructed to write papers based on their theses or dissertations that are then at most grammatically or graphically edited, if at all, and then submitted for publication with the student's name listed as a second author. Indeed, the student's work is not acknowledged. Even if the student listed as a first author, does the mentor's insignificant effort warrant even a second authorship status and does providing funding/stipend for a graduate student with no active involvement in the research warrants any authorship status in first place? In other cases, and again under the disguise of getting experience, the graduate student will be asked to tackle the entirety of reviewers' comments on a journal paper and send them to the mentor and if the students expresses frustration for doing all this work and not even being personally acknowledged for his hard work, the mentor would allegedly claim that this is the role of the student being a first author. Such practices are, like many of the other co-author situations, at best research misconduct and, at worst, fraud. The work presented for publication does not belong to the mentoring author.

There is often confusion that sets in for this form of co-authorship because academics tend to apply the business model of the corporation that is entitled to keep those products and processes that employees develop while employed at the company. Employees may move on to other companies or retire, but their work and work products belong to the corporation to use as it sees fit, including the right to profits from those efforts. However, the distinction for the graduate student/mentor relationship is that the graduate student is groomed with the idea of one day being a colleague, a competitor, of the mentor especially if that mentor is still at the start of his/her academic career. As such, whatever work the student develops in that process does not belong to the mentor or the institution, but, rather, to the student who carries the authority for deciding upon publication and co-authorship issues. This form of co-authorship, one that is also a form of not recognizing a co-author, is perhaps more insidious than the others because the mentor has taken advantage of a position of power in order to advance his/her career at the expense of a student whose educational development has been entrusted to him or her. While most faculty members look at their students as future colleagues who will stand in parity with them and whom they support fully in their development of academic careers, some others would tend to be insecure about their students' potential to success and regard them as competitors. These minority faculty members, and who usually fall off sooner or later in their career, desire to keep their students, if possible, under their supervision and control for the longest possible period of time, and if they cannot keep them for some reason they will tend to do character assassination for them through promoting a refuted lack of collegiality or aggressiveness in dealing within the mentor's close circle of colleagues in the academic community.

The serious problem is that co-author problems in mentor-supervised relationships percolate to the surface only in extreme cases when students are pushed beyond their endurance levels and their sense of justice is offended. Typically, these breaches are hidden secrets because students are at the mercy of academic mentors who control their destinies in everything from the completion of their dissertations to their dates of graduation to the level of financial support they will receive in the form of assistantships. Even after graduation and moving successfully in their own academic career, they tend not to talk about it. Ironically, these suffering students are required to keep the name of their mentor on their reference list for at least the first few years of their academic careers, or they would be raising questions at the evaluation committees. Whatever co-author issues exist, they are not generally disclosed by students for the risk they face of being tainted in the market with the labels of "trouble-makers," "difficult to work with," or "not team players." This particular type of co-authorship issue has been called an area "in need of better control" [21]. Thus, authors think that opinion of former graduate students and who have current academic appointments should be sought when their mentors are applying for promotion/tenure or even new jobs.

Discussion and Analysis

The ethical issues in academic research generally focus on fraud in data gathering, analysis, reporting, funding, and in writing (where issues of plagiarism arise). Indeed, the disciplinary and legal actions and guidelines for researchers also focus on these areas [22, 23]. The forms of misconduct in research are broken down into three tiers, detailed below, with the seriousness of the breach reflected in the categorization of the conduct and the reason for its ranking.

- *Tier One Offenses*; Falsification of data is a tier-one offense because the impact of this conduct is to hamper scientific research because new research builds on the old research and falsified data results in wasted efforts, additional costs, and delays in scientific advancement. For example, falsified research in medicine could result

in physicians developing a plan of treatment for a patient that is not the best one for that patient but was assumed to be based on the falsified data [24]. Co-authorship is not generally considered to be a form of falsification. Yet, a review of the types of co-authorship relationships indicates that editors are, at the very least, mislead about the participation and contribution of the authors. Further, those who rely on the published work in the future assume that contacting those who are listed as co-authors is the means by which they can obtain further insights and information about the work, something most of the co-authorship categories do not guarantee.

- *Tier Two Offenses*; Plagiarism, which is not as likely to cause scientific harm, is a tier-two offense. Self-plagiarism is included in this category and there is significant disagreement about the treatment of both forms of plagiarism. Self-plagiarism can result in multiple co-author relationships across disciplines as co-authors seek to obtain publication of results in journal from different fields. Judge Richard Posner has advocated that plagiarism definitions be narrowed to include those situations in which there is fraud, such as when harm results to competitors (as in the sale of books), the audience for the work (as when subsequent researchers cannot determine the true source of the work and make deeper inquiries into it, which is where co-authorship question fall), and the original source (as when the original author is scientist is discredited because of the subsequent plagiarism or loses funding because of a lack of recognition for his or her work) [25]. The concerns about plagiarism have been compared to the chain of custody requirements with evidence in a criminal case. The evidence cannot be used unless we can establish how it was obtained and who held it during the time between its discovery and its presentation as evidence in court. If there is an unaccounted for use or possession of the evidence then chain is broken and we cannot be certain whether there has been a change in its composition and character [23]. Such is the case with plagiarism; there is a break in the chain of custody of the information and an inability to trace the origins of knowledge or validate the sequence of its development. The presence of a co-author who has not had “possession” of the work or data is a breach in that chain of scientific custody, or at least a breach in the building blocks for later scientific findings that build upon the work.
- *Tier Three Offenses*; This category of offense is where the problems that are the focus of this piece arise, or when there are issues on co-authorship without meaningful contribution, along with issues such as duplicate publications or the “salami slicing” of papers to attain multiple publications [23]. The potential for harm in this tier is categorized as less than that discussed in the other two tiers because the assumption has been that the public is not misled and science is not hampered [26]. However, that assumption was based on norms once used for defining co-authorship. Those norms have shifted. Further, those who do use these third-tier techniques are able to attain funding and institutional rewards that are based on these claims of number of papers and co-authorship status. The classification on the basis of harm requires modification because the definition of co-author is disparate. Daroff [27] indicates that there is a great deal of confusion among academics about what is or is not responsible authorship, confusion that results not from inherent dishonesty but rather from a lack of clarity regarding publication and co-authorship standards.

Unfortunately, the issues of co-authorship misconduct have been relegated to a third-tier level of offense and are not a high priority for investigators or those within the scientific community. Given the categories of co-authorship outlined above, the assumption that there is little to no harm in unfounded recognition as a co-author is incorrect. The status of co-authorship imposes accountability for explanation, retractions, errata, and, for purposes of career advancement, actual contribution to the effort. In the types of co-authorship situations described, it is not clear that the co-authors who are listed will be able to assume these roles that are critical for the ongoing development of a body of research related to their claimed work. The issue of co-authorship is not one that is related to career advancement; rather co-authorship is a form of research misconduct that requires re-establishment of norms so that assumptions about ongoing validity and inquiry related to the work will hold true.

The earlier discussion of the types of co-authors indicates that the definition cuts a wide swath in the academic world. The task of defining co-authorship has proved to be somewhat easier in grants than in articles. Shamoo and Resnik [10] and Olivier [28] agree that in order to qualify for a principal investigator status, the researcher should propose the hypothesis, design the experiments, develop the methodology, and write both the grant proposal and the manuscript. They also provided clarification for the mentor authorship issues by adding that during the process of proposal development, undergraduate or graduate students or postdoctoral fellows may be used only to collect and record data, review the literature, or edit the manuscript. These definitions leave little room for the broadly defined tasks discussed in the co-authorship relationships that involve mentors and students.

However, the ability to list work requirements for article authorship has proved to be problematic. Shamoo and Resnik [10] quoted one of the earliest definitions for an author as: “*someone who has made significant contribution to the project through planning, conceptualization, or research design; providing, collecting, or recording data; analyzing or interpreting data; or writing and editing the manuscript*”. Over the years, this definition was refuted because of its vagueness and such a broad character that would allow a person to be listed as an author, even though this person might not actually know how the project was implemented or whether he or she actually participated in the critical role of the planning of the study. The questions about this definition come from the use of “or” in the various activities with the assumption those alternative activities carry. The “or” structure carries questions as to whether someone who writes and edits but has not participated in the planning stages of the project but would still be able to explain in credible fashion the design and methodology could qualify as a co-author. The definition fails to consider the criticality of reducing results to the written word, a task that mandates a grasp of what was done, why it was done, and what the findings show. Further, all of the forms of co-authorship described earlier do not fit remotely into even this broad definition of co-authorship. Co-authorship as a gift does not involve any of the “or” activities listed here as qualifiers for co-authorship status. Nor does the definition incorporate the disparity in position present in those co-authorships in which an academic with political power over the true researcher insists on parity of treatment in author recognition. The liberal “or” definition, with its flaws, still demands more involvement and effort than any of the forms of co-authorship described earlier.

Others have addressed and disagreed upon co-authorship in more general terms. Shamoo and Resnik [10], Whitbeck [13], Olivier [28], and Elliott and Stern [29] have all agreed that someone should be listed as an author on a paper only if they: (1) have made a significant intellectual contribution to the paper; (2) are prepared to defend and explain the paper and its results; and (3) have read and reviewed the paper. The difficulty with this definition is that it is entirely self-assessed. That is, how is the determination of broad terms such as “intellectual contribution” and “prepared to defend” made and how could these terms be challenged? A type of flip response would be, “It all depends on the meaning of ‘intellectual contribution’”. Some have proposed surrender in the quest for a definition of a co-author and suggested that there be tiers in terms of published results. Davidoff [30] has suggested that all those involved in the published results be itemized as “contributors,” with editors and readers clear on the work each “contributor” did being described in detail. Such a system certainly addresses the needs of readers for further questions and verification but would require the restructuring of the academic evaluation processes. Davidoff [30] solves the accountability problem in terms of scientific integrity but has proposed a system that will require significant acts of conversion in the academic evaluation process. The attempts to define co-authorship may remain an exercise of definitional discretion with the definition and discretion resting with the co-authors and the evidence that they can amass to fit the nebulous and general terms used in these attempts to self-regulate the co-authorship issue. However, co-authorship need not be defined in order to understand when co-authorship is *not* present. If we cannot define a term we can resort to a process of elimination by defining what is not co-authorship. That is, going back to the categories of co-authorship may be a better form of ethical analysis than trying to fit the definition over the categories. In a paraphrase of the U.S. Supreme Court’s standards on defining pornography, we know co-authorship when it is not there more easily than we understand when it is there.

With the definitional issue now relegated to its proper place, the task that remains is establishing whether there is harm from the forms of co-authorship described here. As noted in the definitional discussion of the forms of co-authorship there are benefits that co-authors obtain from being part of a publication or proposal even when they are without any significant contribution to the work. Those benefits include additional grant funding, recognition for the work, and institutional rewards. Further, those in the field presume that co-author status translates into the achievement of the skill levels necessary for the completion of the underlying project. That assumption regarding skill level may lead to the co-author being offered career advancements such as endowed chairs, contributing editor opportunities, summer grant and teaching opportunities, and other monetary benefits. Rewards do flow based on this presumption of both the body of work and ability that come with co-authorship status. In the case of graduate students who must share attribution with their mentors, the harm is the loss of the exclusive recognition that should be theirs, an exclusivity that would provide them with greater opportunities available on the basis of sole-author status. The shifting norms on co-authorship have not taken into account the stakeholders who are affected by the seemingly unilateral and bilateral decisions of researchers to confer co-author status. In addition to the institutional and individual harms that spring from inappropriate co-authorship, there are public policy issues, particularly with regard to research funded by federal grants. Those dollars are public dollars and any undisclosed issues about the authors and/or authorship of the grants, research results, and publications raise questions in the public stakeholders’ minds about both the credibility of the science and the wisdom of continuing federal funding. Public funding

demands transparency. Misrepresentations about co-authorship chip away at transparency. With the loss of transparency comes increasing questions about the wisdom of continued funding [31].

Conclusion

The scientific community is in the midst of an ethical crunch, where the battle for personal short term objectives is controlling the more critically important societal long term goals of transparency and trust in research. As far as the academic civil engineering research community is concerned, Chanson [1] states: “although the problem is still small in absolute numbers, it is a critical issue discrediting the entire profession and the recent trend is alarming”. Albert Einstein wrote, “Many people say that it is the intellect which makes a great scientist. They are wrong. It is character” (quoted by [32]). According to Abraham [3], the complexity of research work and the necessity for multi-centre collaboration are not the only explanations for this trend. In fact, irresponsible authorship has its hand in this inflation where authorship is often used as a vehicle for advancement on personal, social, academic and political fronts [1, 3, 6]. The definition of co-author is no longer uniform nor clear. Those affected by this missing normative standard are not simply the researchers, faculty, and their institutions. The stability of scientific research hangs on the credibility of the researchers’ credibility, both in the conduct of the research as well as in the willingness and ability to continue to provide information and updates as needed to that published information. The problem of co-authorship is not just an internal problem for administrators to resolve with regard to tenure and promotion. The problem is one that crosses all scientific fields and demands discussion followed by some resolution or refining of definition.

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