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Determining the Ethical Use of Engineering Software Programs

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Engineering software programs play a large role in modern civil engineering design practice. A 1993 study by the Columbia Section of ASCE discovered that 95% of civil engineers use computers in their work, and that half of civil engineers use computers during at least 25% of their work day [1]. The pressure to produce designs on time and under budget necessitates the use of engineering software programs. In this work environment, most engineers will at some point be faced with the decision of whether to use a program when they cannot solve the problem by hand, either because of lack of knowledge or lack of time. Since so many engineers will be faced with this decision, it is important to explore how ethics impacts this decision. Therefore, ASCE has posed the question “Is it ethical to use an engineering software program to solve a problem if you cannot complete the calculations manually?”

While I was an undergraduate, my professors were unified and adamant about their answer to this question. You too may initially dismiss the question as having an obvious answer. But before you do, consider your answer to this question: “Is it ethical to use a hand calculator or lookup tables to calculate the cosine of an angle?” We calculate trigonometric functions without ever questioning the ethics. However, few civil engineers know the CORDIC algorithm developed by Volder in 1959 for calculating the sine and cosine of an angle [2]. It is his algorithm that is embedded in most hand calculators. Nor have many civil engineers practiced calculating the sine or cosine of an angle using a Taylor series expansion. The first lookup tables were probably developed using this method. Perhaps the first question is not so easily answered. For the benefit of those wrestling with the decision, perhaps there is a more useful way of viewing the situation.

In order to begin developing an answer about the ethics of using engineering software programs, we should have a common definition of “ethics”. Interestingly, the term is not defined in ASCE’s Code of Ethics [3], so we need to look elsewhere. I will use the Webster’s New Collegiate Dictionary definition that ethics is “a set of moral principles or values; the principles of conduct governing an individual or group” [4]. Accordingly, we can translate ethics to be a set of rules that define what is right to do.

If ethics is a set of rules, who makes the rules? Any individual or group can choose its set of rules. As a society, ASCE adopted its first set of rules in 1914, the Code of Ethics. To help clarify what is right, the Code of Ethics contains “canons” which are standards of judgment. There are seven canons, but two help clarify our question about using

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engineering software: “Canon 1 - Engineers shall hold paramount the safety, health and welfare of the public and shall strive to comply with the principles of sustainable development in the performance of their professional duties.” “Canon 2 - Engineers shall perform services only in areas of their competence.” Let’s see how these canons help answer our question for two different scenarios.

In the first scenario, an engineer predicts peak stream elevations during the design event using empirical flow formulas from a credible agency. The engineer has significant experience predicting peak stream flows in that region and understands the variability of results from the empirical formulas. Based on previous experience, the engineer recognizes the result as reasonable. But as an added check, the engineer uses software that implements the finite difference method to solve the energy equation to predict the peak elevation. In this scenario, however, the engineer does not know how to perform the finite difference method by hand. Is this ethical use of engineering software? The engineer is working within his or her area of competence, so Canon 2 is satisfied. The engineer’s design decisions are based on a conservative estimate of the peak stream flow, so the safety, health and welfare of the public are being looked after. Therefore, Canon 1 is satisfied. Based on the guidance available in the ASCE Code of Ethics, this *is* an ethical use of an engineering software program even though the engineer *cannot* perform the same calculations manually.

In the second scenario, an engineer uses an in-house spreadsheet to calculate the factor of safety for slope failure. The engineer has significant experience in evaluating slope stability and is fully capable of calculating the factor of safety by hand. However, the engineer chooses to use the spreadsheet. The engineer performs the analysis, obtains the output, and makes design decisions based on the output. But in this scenario, the spreadsheet has an error that results in a very high factor of safety even though the slope is actually about to fail. Is this ethical use of engineering software? The engineer is working within his or her area of competence, so again Canon 2 is satisfied. The engineer has produced a design that puts the public’s safety and welfare at risk, and the engineer could have reasonably discovered the error. Canon 1 is not satisfied! Therefore, according to the Code of Ethics, this is *not* an ethical use of an engineering software program even though the engineer *can* perform the calculations manually.

With the prevalent use of computers in civil engineering practice, more and more engineers will find themselves in a situation where they must decide whether to use engineering software programs even though they cannot complete the calculations manually. It is our professional responsibility to do what is right in those situations, but as we have seen from just two scenarios, the answer to our original question is not necessarily clear. To provide better guidance to engineers in these situations, I suggest

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we pose a different question: “Is it ethical to use calculation results when you are unable or unwilling to verify the reasonableness of those results?”

With this question, it does not matter whether the calculations were performed by hand or by computer. It does not matter whether the engineer knows how the calculations were performed or not. But an engineer can only verify the reasonableness if he or she is working within an area of competence (Canon 2). In fact, the ability to verify the reasonableness of results could be considered necessary to be competent in an area. If the engineer verifies the reasonableness of the results, the public’s safety, health and welfare are better protected (Canon 1). But if the engineer has the ability to verify the reasonableness of the results and chooses not to, the public’s safety, health and welfare are at risk. Such would be an unethical decision. As a test of the utility of this new question, consider a third scenario.

An engineer is designing a twenty story building. If the engineer performs all of the calculations by hand, the probability of math errors is very high. The errors could result in an unsafe design that puts the public at risk. In order to meet the project schedule, the design must be performed with engineering software. But hidden assumptions in the software might not match the conditions in the building, so the computer results might not be appropriate for the situation. Therefore, using those computer results might also result in an unsafe design that puts the public at risk. Is it ethical to use engineering software programs in this scenario? We don’t have sufficient information to make this assessment. However, by asking whether the engineer can and will evaluate the reasonableness of the design, we get to the essence of the ethical decision. The engineer can only satisfy Canons 1 and 2 by verifying the reasonableness of the design.

Computers are already an indispensable tool for civil engineers. They allow us to work faster and solve more complex problems. But with that power comes responsibility. Is it ethical to use engineering software programs when you cannot solve the problem by hand? Sometimes the answer is “yes”, and sometimes the answer is “no”. A better question, one that clearly identifies when and how to use engineering software ethically is “Is it ethical to use calculation results when you are unable or unwilling to verify the reasonableness of those results?” If an engineer is unable or unwilling to verify the reasonableness of the results, then it would be unethical for the engineer to use the results. Period!

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