Andrew Kessler
EDC II- Individual Paper (Final Draft)
Professors Ankenman and Duggan
May 17th, 2009

Ethics and Responsibility in Engineering Design

There are innumerable concerns a professional engineer must take into account when designing a product. Issues can cover a wide spectrum, including problems with design, problems with manufacturing, and even problems with users. However, one concern that has serious implications in all stages of the engineering process is ethics. Unfortunately, ethical standards are not as well defined as a project's technical specifications may be, and the implications of these standards can often raise serious concerns throughout the design experience. A student run project is no different. The students involved in the Engineering Design and Communication "Water Bagger" project in the Fall Quarter of 2008 faced significant ethical dilemmas over the course of their involvement, each with its own solution of varying ethical integrity. These issues also serve to establish the responsibility of an engineer as anticipating reasonable misuse of a product and warning against it, as well as the responsibility of the user to respect such warnings.

The project consisted of developing a way for clients of the Douglas Center, a local organization that provides simple yet therapeutic jobs to adults with cognitive disabilities, to assemble instant hot/cold packs. While the task encompassed many individual challenges, the design team decided the most significant problem was to come up with a way for the Douglas Center's clients to safely, accurately, and efficiently measure and heat-seal the correct amount of water for the bags. This particular design problem gave rise to numerous obstacles, many of which were ethical in nature.

For instance, background research along with the client interview revealed that the cognitive disabilities of the users could create communication difficulties [1]. Thus, it was possible that a user could be uncomfortable while using the assembly product, yet unable to express the negative nature of their experience. The Douglas Center made it clear that their primary concern was the therapeutic value their clients would gain from the experience, second only to the safety of the clients themselves. This brought up an ethical dilemma: if the users can't express their discomfort anyway, should a trade off of safety and/or comfort of the users be made for the efficiency of the product? The question was worth considering because the team had not yet decided on a final design, and was considering alternatives that were less "user friendly" yet more efficient economically.

In this case, the answer to the ethical concern was quite clear. The Douglas Center stressed that its first and foremost concern was the well being of its clients. Therefore, the team conducted significant user testing, along with extensive interviews with Douglas Center employees regarding cognitive disabilities, in order to ensure that the user was as safe and comfortable as possible, regardless of its effects on the efficiency or cost of the product.

The team clearly made the right call, because sacrificing safety for cost effectiveness would have been ignoring the client's top priority. It would also go against one of the main points of *The Code of Ethics for Engineers,* which says "engineers shall hold paramount the safety, health, and welfare of the public." [2]. This conclusion is also confirmed by analysis of the Kansas City Hyatt Regency Walkway Collapse, where designers did choose to sacrifice safety for convenience. In July 1981, supports holding elevated walkways in the Kansas City Hyatt Regency broke, causing them to fall onto the

crowded lower level. The incident resulted in 114 deaths and over 200 injuries [3]. The cause of the event was attributed to “the changed design from a one-rod to a two-rod system to simplify assembly”, which doubled the load on a connector and led to failure. This case epitomizes the idea that trading off safety for efficiency is unacceptable, and can potentially be quite dangerous. It also supports the Water Bagger design team’s decision to make safety their first priority in the previous example by choosing the design alternative that maximized this quality.

A similar problem presented itself during the prototyping process, where the team had designed an aluminum tray to hold the water bags. The issue involved the corners and edges of the tray, which were periodically sharp as a result of the machining process. The team found that even with extensive filing, it was nearly impossible to eliminate all the sharp edges of the tray. They planned to use strips of rubber to line the tray, theoretically protecting the users from the sharp edges. However, the necessary rubber lining could not be acquired by the project’s deadline, thus an ethical question was raised: since the product is currently unsafe, and the item to make it completely safe can not be obtained, should the team abandon the design entirely, or give the client a potentially unsafe product?

The answer to this question is not so clear, especially considering the impending deadline. Because there was no time to develop a replacement product, the team decided to line the edges of the tray with electrical tape, which, while not solving the safety issue completely, certainly removed a significant portion of the risk. The team warned the Douglas Center of the possible safety issue, and advised them to use the product at their discretion, considering they are most familiar with what is and isn’t safe for the clients.

This was again a good choice on the part of the design team, because any other option, such as trying to start a safer design from scratch, would have left them without a completed prototype. Keeping the current product as it was didn't put anyone in significant danger, especially considering that the Douglas Center was warned.

It is reasonable to argue that no prototype is a better than an unsafe one. But, it is important to keep in mind that in this case, the final decision of whether or not to actually use the prototype rests in the hands of the client, the Douglas Center. If the Douglas Center is presented with the potentially unsafe product, they have the power to decide not to use it if they think it is too dangerous. Alternatively, they may think that the advantages of the product outweigh its potential dangers, and may decide to put it to use. As mentioned above, this is the decision of the Douglas Center, because they are the experts in what is and isn't safe for their clients, much more so than the design team. Thus, as long as the product isn't unreasonably dangerous and does have a productive application, it is clearly better to go ahead and deliver it to the client. However, this may not be the case for all projects, because there may not always be a "middle-man" like the Douglas Center to decide whether or not the product is safe for the end users. In such a case, the engineers responsible for the design would have to seriously consider not delivering a final product at all if it was even marginally unsafe.

Another option that the team had in this case was to make the same design out of another material, such as a polycarbonate, that would not have dangerous sharp edges after being machined. However, in this case the team did not have the resources to purchase such a material. But had they been able to afford the new material, this also would have been an ethically sound choice because they wouldn't of had to waste time

designing a new product (thus their safety tests would still be applicable) and the edges would have been safe to handle.

A third ethical concern that arose during the design process actually presented itself similarly in two different instances. The first involved the usage of both water and electricity in the product. Allowing parts of the product to be electronic greatly improved the efficiency and simplicity of the design; however, the fact that it would be used for measuring water presented a possible electrocution concern. Fortunately, significant testing and research by the team revealed that taking into account the type and quantity of the electricity being used, the risk of electrocution was minimal, even with the inclusion of water into the product. However, a pressing ethical concern still remained, because these observations were focused on the product being used as intended. If the product was misused in a certain way, it was possible an electrocution risk could still exist. This brings up an interesting question: just how far does the design team's responsibility go? How much "extra" effort should they put in trying to anticipate every possible future action of the client that could cause them to be harmed by product misuse?

This same question presented itself elsewhere in the project, in another major element of the team's design: an automated water-measuring device known as the "double buret". The double-buret consisted of a tube of a specified volume, with valves at each end. Water was fed in through the top valve with the bottom valve closed, and when the tube filled, the top valve closed and the bottom valve opened, releasing the water. The volume of the tube was specifically designed to be the same as the volume of water needed in each bag (eight ounces).

The problem here arose around the issue of accuracy. While the buret was designed to consistently provide the correct and same amount of water each time, there was a small but noticeable discrepancy between the actual volumes outputted from the device between each use. Fortunately, the client stated that the eight-ounce volume of water required was an estimate that was reasonably adjustable within the limits of the buret's error, so precision was not a huge concern. But like before, an ethical problem remained involving the client's future use of the product. About halfway through the design process, the Douglas Center informed the design team that they would possibly be interested in using this liquid measuring product for future (yet to be determined) applications, where accuracy may an important concern. Again, the question arose: do the responsibilities of the designers include accounting for every possible use of the finished product?

To find an answer to this question, a distinction must be made between "future use" and "misuse". In this discussion, future use is considered any application of the product, whether or not the designers intend it. Similarly, "misuse" is considered future use that is not explicitly approved by the designers of the product, and may cause harm to the users or cause the product to not function as intended.

Finding the right answer to the dilemma that arose in these two cases is difficult. According to the *Code of Ethics for Engineers*, "engineers shall perform services only in their area of competence." It goes on to say, "an engineer shall advise their clients…when they believe a project will not be successful" [2]. Taking this information into account, the design team decided to continue with their design as originally intended, but warned the Douglas Center of the product's potential problems in future, unintended applications.

While it's true that the team could have started from scratch with a new design intended to meet most future needs of the client, it's likely that there wouldn't be time to thoroughly complete safety tests. Thus doing so would have gone against the *Code of Ethics* ("Engineers shall hold paramount the safety of the public"), which was also one of the client's biggest concerns. By staying with their original design, the team obeys the *Code of Ethics* by completing their project to the best of their ability in the area they are familiar with and informing their client of any shortcomings their design may have in the future. Via this reasoning, an acceptable answer to this ethical dilemma can be reached: it is preferable for the team to make the design they are familiar with as safe and efficient as possible, as opposed to trying to predict every possible future use of the product, which in such a short timeframe would likely produce an unsafe result. Of course, this is assuming that the client is then warned of the potential consequences of misuse.

However, from a legal standpoint, several past cases have established the idea that designers are responsible for anticipating foreseeable and reasonable misuse of a product. For example, a case that dealt with a young woman whose shirt caught on fire while using an electric stove established that "accidentally brushing a stove burner is a foreseeable misuse of clothing, and that the [shirt] manufacturer had a duty to warn of such foreseeable misuse." [4] Even though the designers didn't intend for the shirt to be used while cooking, it was still considered "reasonable" misuse and should have been accounted for with at least a warning.

While it is not a legal case necessarily, the *Challenger* incident brings up the point that a simple warning may not be enough. In January 1986, the *Challenger* space shuttle exploded shortly after launch, killing the seven space-bound passengers. Among the

causes for the tragedy, one was the fact that the solid rocket booster “O-rings”, which caused the explosion, were not meant to be used in temperatures as cold as they were at the launch [5]. The engineers anticipated this type of misuse, and warned the NASA officials of the danger of misusing the “product”. However, this was obviously not made clear to those in charge at NASA. This shows that any potential shortcomings of a product during foreseeable “misuse” must not only be communicated to the client, but also presented in such a way that the client fully understands the danger involved.

Finally, a case in August of 2004 involved a man who accidentally cut off one of his fingers while misusing a table saw. He claimed the designers of the product were at fault because there was improper warning that this was a danger [4]. However, he failed to read the instructions to the product, which the court found to be a breach of the warranty and that fault lied with the user as opposed to the designer. This case showed that not only is it the responsibility of the designer to warn against possible dangers, but also the responsibility of the user to carefully follow all warnings.

These three cases have established somewhat of a guideline for engineering responsibilities: not only is it the responsibility of the engineer to anticipate reasonable misuse and warn against it effectively, but it is also the responsibility of the user to follow such instructions. But just how far does the engineer’s responsibility extend? The document *Restatement (Third) of Torts: Products Liability*, which provides legal guidelines for product misuse cases, summarizes effectively: “product sellers and distributors are not required to foresee and take precautions against every conceivable mode of use and abuse to which their products might be put. Increasing the cost of

designing and marketing products in order to avoid the consequences of unreasonable use is not required." [6]

Based on the above definition, a fitting description for "foreseeable and reasonable misuse" seems to be any consequence of misuse that can be anticipated with routine safety tests during the design process. For the specifics of how designers should fix the dangers of reasonable misuse, referring to UL Standards may be helpful (especially for electrical elements), as well as deferring to the client, depending on their knowledge of the topic. Finally, it is important to remember that then the client must be effectively warned of the consequences of such misuse.

Taking all of this into consideration, it is a reasonable conclusion to say that the design team assigned to the "Water Bagger" project made ethically satisfactory decisions. By testing the consequences of combining electricity with water and the measuring mechanism's error, the team used their resources to the best of their abilities to anticipate reasonable misuse of the product and to warn the Douglas Center of the dangers of such misuse. Thus, according to *The Engineer's Code of Ethics*, *Restatement (Third) of Torts: Products Liability*, and the ethical responsibility guideline just developed, it can be said that the team fulfilled their responsibility to their client both by designing a functional and non-dangerous product that met the requirements put before them, and by clearly warning the client of the dangers of potential misuse of the product.

References:

[1] Gardner, Rod. Personal Interview. 08 Oct 2008.

[2] "Code of Ethics for Engineers." *National Society of Professional Engineers*. Jan 2003. 11 May 2009 <http://www.mtengineers.org/pd/NSPECodeofEthics.pdf>.

[3] Rabins, Mike, Charles Harris, Michael Pritchard, et. al. "The Kansas City Hyatt Regency Walkways Collapse." *Engineering Ethics*. Texas A&M University 11 May 2009 < http://ethics.tamu.edu/ethics/hyatt/hyatt1.htm>.

[4] Dell'Osso, Daniel. "Avoiding the 'misuse' defense in products cases." *Access My Library*. 01 FEB 2002. Association of Trial Lawyers of America. 18 May 2009 <http://www.accessmylibrary.com/coms2/summary_0286-25117054_ITM >.

[5] Rabins, Mike, Charles Harris, Michael Pritchard, et. al. "The Space Shuttle Challenger Disaster." *Engineering Ethics*. Texas A&M University . 11 May 2009 <http://ethics.tamu.edu/ethics/shuttle/shuttle1.htm>.

[6] Henderson , James and Aaron D. Twerski. "Restatement of the Law Third, Torts: Products Liability." *American Law Institute*. 1997. 18 May 2009 <http://www.ali.org/ali_old/promo6081.htm>.