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Advanced Materials—Any Ethical Questions? Study*

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This paper describes how three professors from diverse academic fields—sports, ethics and metallurgical engineering—came together to teach a class in ethics, competition, and advanced materials technology. The dual focus of the course was: (1) on the growth of technological advances in sport equipment design, and (2) on the ethical questions that could and should be asked when such advanced designs alter what is generally human practice. Class enrollment was 21 college age junior science majors.

INTRODUCTION

WITH THE GROWTH of technological advances in materials and their application in sporting equipment, equipment design has changed dramatically in the last few years. With the new titanium drivers and high tech composite balls, golf duffers are now able to hit the ball further and more accurately than they could before. Tennis, racquetball, and squash amateurs are able to hit balls more efficiently and supposedly play a more respectable game with racquet heads which are now almost twice as large, and with a greatly enlarged 'sweet spot'. Advanced materials have revolutionized the materials of fabrication in bicycles, skate boards, surf boards, skis, snow boards, javelins, golf clubs, golf balls, tennis racquets, football helmets, playing surfaces, baseball and softball bats, ad infinitum [1–5]. It is doubtful that a sports implement exists that has not been affected positively by the use of advanced materials. In some cases, this positive influence increases comfort and avoids injury—such as the modern day running shoe.

Considering these advances and considering that two of the three authors of this article were involved in advanced material design, we began a discussion. When we revolutionize and change a sport activity because of advanced material design:

- Does it have any sort of ethical repercussion to the choices that individuals make when they play the concomitant game?
- Is any harm done when these advanced materials revolutionize sport and change practically all aspects of the respective game?
- Should individuals involved in the development of these advanced materials have some sort of ethical training to ask these types of questions as they proceed in scientific discovery?

As we haggled over these questions, one of us pointedly asked the other two if we were willing to take up the challenge to actually teach a class of university-aged undergraduates about such ethical questions. The challenge was to focus the class on five points.

1. What are the new advanced materials that are affecting sport today?
2. What occurs to the sport, the history of the sport, and the games played when these advanced materials become the materials of choice?
3. What harm, if any, occurs when advanced materials revolutionize sports implements?
4. What good, if any, occurs when advanced materials revolutionize the sports marketplace?
5. What trade-offs occur when advanced materials revolutionize the game?

The outcome was that we decided to teach a class for undergraduate students in ethics and advanced materials. The idea was rather simple, to combine a professor who is well known in the development

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of advanced materials with a professor who is well known in the teaching or moral reasoning and let them have a third professor to act as referee and keep the class and professors on task. It all seemed rather easy to do, if we could just work out the strategy of how to do it.

THE CLASS DESIGN

The two-hour class met twice a week and was offered as an upper level core selection in humanities and social sciences with 21 students electing to take the class. At our institution, the requirements for a baccalaureate degree are fulfilling the general-education or 'core-curriculum' requirements. These courses are intended to meld the liberal learning of the humanities and social sciences with the professional education found in the various colleges. These 'core curriculum' courses introduce students to a variety of disciplines and perspectives on topics of broad interest. Our purpose in our advanced materials/ethics class was to meet these criteria and our hope was that the majority of students would be engineering, chemical engineering, or computer science majors. Few of them had any background or experience in moral reasoning or ethical study [6, 7].

Because the students had no background in ethics, the class began with a three-week brief introduction into moral reasoning. The class methodology was based on what Jerry Gill [8] has called 'a dance' of discussion. The class was not professor-centered but student-centered with the professors challenging students with questions that were addressed amongst the students and between the professors. It was also not uncommon for a professor to challenge another professor, or the students to challenge each other and the professors. It was a rewarding experience.

Topics covered within this period of time focused on:

1. What are ethics? What are moral values? What are social values? Do universal moral values exist? Why be ethical or moral? What is relativism? What is cultural and ethical relativism? What are professional codes of conduct? What are ethical guidelines? What are the ethical guidelines of engineers and scientists?
2. What is moral reasoning? What is its purpose? How does moral reasoning relate to ethical judgment? What tools can be used to support moral reasoning? Why do moral reasoning?
3. What is duty? What is ethical responsibility? What is the harm principle? How does one formulate an ethical question in a relativistic society? How does one make an ethical judgment?

After this basic 'foot wetting' of the moral process, the students began their journey in applying moral reasoning to the world of advanced materials as related to sport equipment. The actual process design of the class was based on three parts:

- presenting to the class information on advanced materials in sport (which turned out to be very fun considering the number of recreational athletes in class who were experts in their own right in certain sporting activities);
- hearing from guest lecturers, 'sport experts', who actually either helped design new equipment using advanced materials, or used the advanced materials in the sporting world;
- writing ethical papers on advanced materials and sport use which forced on a thinking and reasoning process about this subject matter.

Each student was assigned six papers to write on such topics as:

1. What is the purpose of the activity that is affected by advanced materials? Is the purpose to get a human from one place to another efficiently, i.e., transportation? If the answer is yes, then the moral ramifications would be very different than one of the following. Is the activity's purpose to test a human skill? Is the purpose to test athletic preparation or psychological preparation? If this were the case, then the moral considerations must address how the activity violates the human participant. To say this another way: If the purpose of the activity is about human action, does the use of this new material negatively or positively affect the purpose, and how does the new material negatively or positively affect the 'humanness' of the participant?
2. What moral values are violated with the use of these new materials? That is, does the new material or could the material potentially harm a human, or any other sentient being? If any harm is done to the participant because of the effectiveness of the material, then one needs to consider what must be done to avoid harm. Generally the harm principle argues that we have a responsibility to our fellow humans to do no harm and remove harm. And, does the new material violate the notion of fairness? Would the use of this material place one at an advantage such that the level playing field is diminished?
3. Just because we can do something as a result of science and technology, should we? If we do choose to extend our use of science and technology, what are the ethical/moral responsibilities or consequences of that use? What does it mean to treat the human body as an improvable and perhaps perfectible machine? At what human cost would these machines be effective?
4. Will this technology contribute to the dehumanization and alienation of athletes from their sport world or from themselves? How should this be considered in relation to the human condition and participation in sport? This ethical element applies to nearly every

sport: change the equipment—make it lighter, faster, stronger—and you change the athlete. What should be our concern if the design of equipment determines the type of athletes who can participate?

5. Should the athlete have a role in the application of technology? Is it possible that because of the concern for improving performance, the human becomes little more than data points on a computer printout? What occurs to the concept of human agency when athletics and participants see themselves defined or described by body composition assessments, anxiety test scores, personality inventories, temperament type indicators, force application determinants, and so forth? When technology becomes the focus, what then becomes of the autonomy of the participant? If participants and athletes become submissive and controlled by the environment, what then occurs to the moral development of the individual? Should sports be for the participants or the technology? What ethical guidelines protect the participant? Should the benefit to performance outweigh the potential risk for the athlete? [9]
6. Does the athlete have a moral right and perhaps responsibility to know the potentially damaging 'side effects'? Should they have the option to consent or not consent to the new technique, procedure, or equipment under non-coercive conditions? Should the athlete also have the same right as any research participant to withdraw from the 'treatment' at any time without penalty? Therefore, should informed consent be a moral responsibility of those in administrative positions? [9]

THE CLASS IN ACTION

Little did we know that teaching such a class would be so challenging, not because of the professors, who we thought might have personality conflicts considering their diverse backgrounds, but the class became a challenge because of student doubt about the worth of such a course. As we began our process, the students were very cynical about 'learning ethics'. Basically, they would argue that:

- 'Science and ethics don't mix.'
- 'This is about sport, not about human cloning. If we can make it, why shouldn't we?'
- 'Science should not be encumbered with answering ethical problems, after all science is above ethics. Science is more important.'
- 'We scientists know what's best. We don't need silly little classes to discuss what anyone with common sense would already figure out.'
- 'Everyone knows what's right and wrong, so why are we wasting our time with these sorts of classes.'

However, changes began to occur as the class progressed and the assignments were addressed. The first three weeks was rather a 'blood letting' process as the students challenged each other and the professors. The students were highly competitive in showing their knowledge and expertise and that ethics was either a non-issue or that all scientists have basically an 'ethics' gene that answers and addresses all problems. In all but two of the first papers written, the students were quite clear that 'everyone knows the right thing to do'. Apparently in their scientific studies or their interpretation of the scientific process, they, as students, were brighter than the average, and intelligence was definitely equated to moral supremacy. However, with concerted effort by the professors, i.e. giving argument and examples of how scientific hubris has been the cause of much harm in this world, humility began to win the day as students realized that as one of them said, 'Perhaps, we do need ethics . . . I thought all of this was rather useless . . . but now, I'm thinking differently.'

Class presentations

After the three-week introduction, the students began their presentations on advanced materials. It was interesting to watch as they discussed and challenged each other about what they had discovered. On the whole, they asked few difficult ethical questions of each other. Rather, they focused on the exploits of how they personally used advanced materials to do 'risk-seeking' adventures. One young man was quite proud that his new composite bicycle permitted him to slip stream behind a semi-truck and reach speeds of 60 mph. Another was very adamant that one hadn't lived until one had downhill ski raced at 70+ miles per hour. After all, if the material lets one do these sorts of things, then one must take the challenge. Few students challenged any of this shallow thinking. None of them asked such questions as: 'Do you owe anyone responsibility when you take such risks?' 'What harm is done when one chooses to take such risk?' Instead, the students basked in the risk taking of their peers and let the professors ask the 'tough' questions of harm, paternalism, and autonomy. When confronted with the question, 'If you hit a tree at 70 miles an hour, other than the fact that you are dead, what harm is done?' The students had difficulty looking beyond the obvious points of 'cleaning up' a dead body. They had not thought about the responsibility of autonomous behavior and its effect on family, friends, and community. Neither had they thought about the paternalistic responsibility when one is an advanced materials engineer who has the capacity to develop a sport implement that is lethal. They had difficulty with addressing questions such as: 'Just because we can make a bicycle that can withstand speeds of 60 miles an hour, should we do it, when the human body cannot withstand a fall at 60 miles an hour?'

The sport experts

However, such detachment was not the case when the 'sport' experts, guest lecturers, came to class. In each and every case, the sport experts were challenged loudly and critically about their view of advanced materials and sport ethics. A golf professional when introduced, chuckled and said that the class topic, the study of ethics in sport, seemed rather silly. He pointedly said that in some sports, 'It's only unethical if you're caught, which is not the case in golf which is ''self-policing''.' The class basically got into a heated, somewhat competitive, argument with the golf professional about why ethics should be guidelines for what and who one is. Unfortunately, the poor man was not prepared for this sort of a repartee. After that incident, the students championed the notion of ethics to every guest presenter in class, almost as if they had a competitive urge to show what they had learned and how 'unlearned' the professional expert was. This included the University President, who had apparently been a very competitive sportsman in his younger days (whose competitive spirit is now challenged in other ways). At first, we weren't sure if our students were really focused on 'ethics' and the responsibilities that come with ethical/moral reasoning or if our students were basking in the hubris of being very bright, very articulate, and very able to take what knowledge we had given them to bash a brash, arrogant individual. That question was not answered until we reviewed the class and charted their thinking through their written papers.

THE WRITTEN ETHICAL PAPERS

What was most remarkable about the class was the change in the reasoning process of the students as they wrote their six papers. As their papers were graded and assessed, the moral reasoning professor asked many, many questions about their reasoning and their arguments for why they supported each position. Over the 16-week period, it was rather obvious that the students became more thoughtful about their points of view and were not so 'flippant' about ethics and sport equipment. Questions were addressed thoughtfully by the students such as:

- 'Just because we can make something, should we?'
- 'Just because science can create, should we?'
- 'What harm is potentially done by this new application, this new process?'
- 'What ethical role do you play as a scientist?'

Subjectively, one could argue that they got better in their reasoning because we wanted them to. That may be true, but objectively, other data also suggested that their thinking was being piqued.

1. Their papers got longer. They were required to write 3–5 page papers, which at the end of term turned into 5–7 page papers.
2. Their references to themselves markedly increased as they wrote their papers. They personalized the ethical discussions and shared many ethical dilemmas that occurred to them and their friends.
3. They offered references for the professors to read or brought in books, journal articles, newsprint, and magazine treatises on ethical topics that they found important.
4. A few asked the professors to review their employment application letters and give critique on how they could make a clear philosophic statement about their ethical position as a scientist.

STUDENT EVALUATIONS

At our institution, undergraduate students evaluate every class using a blind response inventory. On a likert scale of five points: excellent, above average, average, below average, and poor, 20 students rated the class as excellent or above average. One student rated the class as poor. On the subjective, written comments of the evaluation, the 20 positive students said:

- 'We went over a lot of different material and applied it to real applications.'
- 'This was a very thought provoking course. Probably the most fun that I have had during my college experience.'
- 'I thought the material and the different aspects of ethics as well as the engineering aspect were very well presented and very informative.'
- 'The strong emphasis placed on ethical morals in relevance to each individual.'
- 'The class was interesting and effective.'
- 'They really went into ethical questions which are not always discussed but are good to think about.'
- 'I really enjoyed the way this course really made me think a lot about the issues covered. Also, I believe that I will retain almost everything I learned because it was so interesting.'
- 'It was nice to hear everyone's opinion on things. The course covered a lot of ground and interesting topics.'
- 'Great class format and open interaction.'

The student who rated the class as poor, made no written comment.

SUMMARY

On reflection, teaching this class about advanced materials and ethics was found to be very stimulating as teachers and terribly enlightening as scientists. We learned much about ourselves, our subject matter, and the students by being involved in this process.

The students

Students need such classes to challenge them to think beyond the scientific paradigm. If our students are typical of most undergraduate college age students, few of them had ever thought about ethics and science. To them, science was some sort of elevated endeavor in which just because they were involved in the process would give them an enlightened sense of what was the right thing to do. Few of them had ever thought outside the paradigm of their own fields. Most of them appeared to be quite arrogant of who they were. They seemed to believe in the infallibility of science and languished in their own hubris of 'being quite intelligent,' thus were beyond the need for such a 'lowly, useless subject' as ethics. If we accomplished nothing else, this barrier was broken and all but one of 21 realized the importance of thinking about such things as 'harm', 'responsible science', and 'duty to others'. This in itself justifies and supports the need for such classes in ethics and advanced material design.

The professors

The class and its teaching together have sparked a new direction for all three authors. Objectively, the professional relationship has resulted in a combined partnership of international scholarly presentations, grant writing activity, and published papers. Our teaching, specifically our subject matter and teaching methodology, improved in that the two advanced materials professors now use ethical discussion as pivotal points in their classes, and the sport philosophy professor offers more content on technology and ethical dilemmas. Our teaching and our students are the better for this teaching partnership. Subjectively, the partnership has resulted in mutual respect for each other and our respective disciplines. And, the best part is—we are scheduled to teach the class again, next term.

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