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Promoting Safety through Economics Education

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Abstract.

Economics is an important topic that is receiving increasing interest in curricula across the United States. A novel approach for teaching safety has been developed by embedding safety stories into

economics instruction curricula. A four step process is used. First, a narrative is read and discussed that informs the student of a safety problem, e.g., crushing injury from a tractor overturn. Second, a case analysis is conducted to identify an intervention that would control or prevent the hazard and to develop cost factors related to the incident. Third, a decision analysis using a decision tree compares the injury outcomes with and without the intervention for a population at risk, and fourth, an economic analysis applies costs to the intervention and the time-value of the cost for injuries averted and associated indirect costs. The result of the economic analysis is many-fold. It can show the cost-effectiveness of the intervention. It can provide a benefit/cost ratio, breakeven point (payback period), and expected cost (value) of an incident with injury potential. Four narratives have been used in analyses taught in high schools and college classes (agricultural management): tractor overturn, fall from horseback, roadway collision involving farm equipment, and noise-induced hearing loss. Important principles of cost engineering are taught including present value, inflation, opportunity cost, social cost, and both the direct and indirect cost of an injury.

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Keywords. cost, benefit, economics, safety, decision analysis

Introduction

Part of the education for agricultural and biological engineers is cost engineering, and an important part of such a curriculum is understanding risk. A technique has evolved over the years for understanding the linkage of the risk of injury on farms with the economic cost of those injuries (Leigh et al., 2001).

Economics has a powerful influence upon work processes in farming. The paring of a narrative with a Farm Planning Tool has been recognized as a way to bring economics and safety together for more effective changes in safe behavior (Scharf et al, 1998; Isaacs, 1997). Many risks on the farm are low probability events, which many farmers subjectively discount as unlikely. However, when the cost of injuries or fatalities is factored into the logic of injury prevention, protective technologies have been shown to be cost effective from a social perspective (Myers et al., 2004, Myers et al., 2005).

Research has shown that farmers make cost-benefit analyses subjectively and do not make decisions based upon an accurate accounting of direct and indirect costs (Kidd et al., 1998). A farmer's attitude is an important factor in subjective discounting of injury risk, but if the farmer "feels" safer with--as an example, a rollover protective structure (ROPS) on a tractor--they are more likely to invest in the protection. In affecting safety behavior, knowledge in not enough; attitudes also need to be changed. To change attitudes, stories have been used that illustrate different hazards on the farm and the consequences of these hazards when an injury occurs (Cole, 2000).

Engrained attitudes against taking actions that improve safety depends upon severe costs or that may involve the death of a family member, but attitudes can also be changed by modeling another person's behavior and internalized stories about the other person (Cole, 2002). In work in student learning, Mazur et al. (2005) has observed that instruction effectiveness can be enhanced by engaging students through personalizing hazard recognition, placing injury reports into a context that are easily understood, demonstrating the complexities of making choices related to safety, and attending to the consequences of injury incidents.

In 2004, the University of Kentucky launched a study in which high school students were taught economics by using narratives regarding protection against injuries. This study used two teachers in each of four counties as part of this effort. After the first year, the study was simplified for the high school students (the target audience was 11th grade students). However, the more complex version of the exercises was used in high school accounting classes and by one of the investigators in college-level agricultural management classes. The objectives of the study were to address the following questions through the application of economic concepts:

1. Who in the community is at risk of these types of injuries?
2. What are the costs of these injuries, and who bears these costs?
3. In what ways can these injuries be prevented, and why is it cost effective to do so?

Economic concepts were derived from the definition of economics: the study of production, distribution, and consumption of goods and services. The State of Kentucky requires that their students understand how their economic decisions affect them, others, and the nation as a whole. Riggs (1977) has recognized that engineering economics can be understood by examining the different dimensions of "cost." The education of agricultural and biological engineers could be augmented with the complex version of the curriculum developed in this study. This paper describes that version of the curriculum.

Method

The method used in this curriculum involved four steps. The first step uses a handout exercise, whereas the second, third, and fourth steps use a combination of written instructions and a computer-based spreadsheet. The internet may be used to collect some data in the exercises. These steps are described below.

Narrative

The first step was the use of narratives used for changing the attitudes of farmers in previous applications of “stories to live by” (Cole, 1997). These stories establish relevance of safe actions in the real world. They also tell of injury events that are easily remembered. The narrative approach is more effective than statistics when the audience is reluctant to accept the message (Morgan et al., 2002).

Case Analysis

The second step was the continuation of the story with an analysis of the case to determine cost factors that relate to the injury incident and identify one or more interventions that would have prevented the injury and the associated cost of the intervention (Myers, 2000). The effectiveness of the protections was also determined. This analysis also examined the different cost perspectives associated with the injury. Across the different narratives used, these perspectives included that of society (all costs included), the farmer, a rural household, a non-farmer victim’s family, and an employer of a non-farmer victim.

Decision Analysis

The third step was a decision analysis that moved from a case to a population to determine the risk of the injury (Myers & Pana-Cryan, 2000). In a decision tree, the risk of the injury with and without the intervention was compared, and the difference in the risk provided the increment of protection provided by the intervention. The result of this analysis was the increment of injuries averted as a result of the intervention.

Economic Analysis

The economic analysis associated costs with different levels of injury severity and calculated the costs of the injury over a time horizon, e.g. the potential remaining lifetime of the victims (Pana-Cryan & Myers, 2000). These costs included both direct and indirect costs and represented the cost of no protection as compared with the cost of the protection. Taking these costs together with the cost of the intervention, several analyses were conducted. These analyses included a cost-effectiveness analysis, a benefit-cost analysis, a breakeven analysis (payback period of an investment), and an expected value analysis (illustrates low probability, high cost consequences). The costs were discounted to arrive at a present value based upon a 3% social discount rate, and inflation for past cost figures were adjusted using the Consumer Price Index, which was available at the U.S. Bureau of Labor Statistics website.

Results

Four narratives were used in this study. The first narrative involved a tractor overturn, the second a fall from a horse, the third the chronic effects of noise-induced hearing loss, and the fourth a roadway collision between an automobile and a tractor towing farm equipment. All of the analyses that followed the narrative involved the entry of direct and indirect costs into a

spreadsheet program (Excel). The program was designed to show graphs that changed as the data was entered by the student. Several worksheets were used to rollout the analysis in a cascade fashion with a companion instruction document that started with the case analysis, followed by the decision analysis, and concluding with the results of several economic analyses. The concepts taught through each of the four narratives are shown in Table 1.

Table 1. Concepts Taught with a Narrative Driven Cost Analysis Tool

Steps after the Narrative Exercise	Narrative			
	Kayles Difficult Decisions	**Heather on Horseback**	**Sound Advice throughout the Years**	**No Way to Meet a Neighbor**
Case Study	• ROPS • EMS • Risk • Risk factor. • Benefit • Scarcity • Economics • Microeconomics • Macroeconomics • Intervention • Cost (of inputs) • Opportunity cost • Explicit costs • Implicit costs • Direct costs • Indirect costs • Price • Distribution • Annual exposure	• Annual exposure • Benefit • Cost (of inputs) • Direct costs • Discount rate • Discounting • Distribution • Economics • Explicit costs • Implicit costs • Indirect costs • Interest • Intervention • Macroeconomics • Microeconomics • Opportunity cost • Present value • Price • Scarcity • Analytic horizon	• Annual exposure • Benefit • Cost (of inputs) • Decibel • Direct costs • Economics • Economies of scale • Indirect costs • Intervention • Noise • Opportunity cost • Price • Scarcity • Social cost • Supply & demand	• Annual exposure • Benefit • Cost (of inputs) • Direct costs • Distribution • Economics • Entrepreneur • Indirect costs • Insurance • Intervention • Labor • Macroeconomics • Microeconomics • Opportunity cost • Price • Productivity • Risk • Scarcity • Social cost • Workers' compensation
Decision Analysis	• Disability • Decision analysis • Decision tree • Sensitivity analysis • Loss control • Maximum Abbreviated Injury Scale • Probability	• Disability • Decision analysis • Decision tree • Sensitivity analysis • Loss control • Maximum Abbreviated Injury Scale • Probability	• Disability • Decision analysis • Loss control • Probability	• Disability • Decision analysis • Decision tree • Loss control • Maximum Abbreviated Injury Scale • Probability
Economic Analysis	• Discounting • Discount rate • Expected Value • Time horizon • Inflation • Productivity • Entrepreneur • Market • Cost analysis • Cost effective • Cost-effectiveness analysis • Benefit/cost analysis • Present value • Cash flow	• Expected Value • Productivity • Entrepreneur • Market • Cost analysis • Cost effective • Cost-effectiveness analysis • Benefit/cost analysis • Cash flow	• Expected Cost • Inflation • Productivity • Entrepreneur • Market • Cost analysis • Cost effective • Cost-effectiveness analysis. • Time horizon	• Analytic horizon • Benefit/cost analysis • Cost analysis • Cost effective • Cost-effectiveness analysis • Discounting • Discount rate • Entrepreneur • Expected Cost • Inflation • Market • Productivity • Present value

Kayles Difficult Decisions

The Kayles Difficult Decisions narrative involved a youth who was a victim of a tractor overturn in which the tractor did not have a ROPS and seatbelt mounted (Cole et al., 1997; Kidd et al., 1998). This case identified the intervention as a ROPS and seatbelt at a cost of $795. The incident involves a teenager who is operating a non-ROPS tractor when it overturns. The injury outcome was incapacitation with injuries for 6 months. The cost: to society was $152,780 that included $71,980 to the farm household. Figure 1 shows the reduction of deaths and severe injuries associated with placing a ROPS on a tractor.

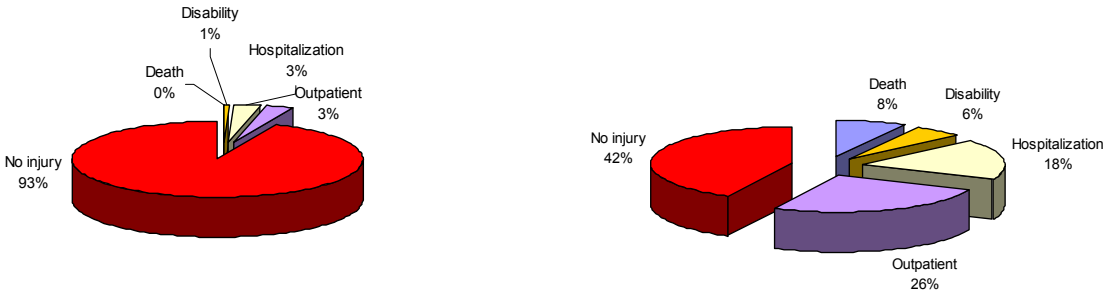


Figure 1. Injuries with A ROPS vs. without a ROPS.

Heather on Horseback

The Heather on Horseback narrative involved a 13-year-old girl who fell from her horse and suffered permanent brain damage. The case study identified a riding safety helmet and continuous parental supervision as the intervention at a cost of $3,342 (5-yr period). The incident involved a teenager falling from her horse, and she was not wearing her safety helmet. The injury outcome was a serious brain injury with no cure. The cost was $4,837,847 to society that included $1,644,434 cost the victim's father. Figure 2 shows the source of funding for the lifetime care of a victim of permanent brain injury, whereas Figure 3 shows the cost of interest when observed over a five-year period. Both of these figures are the result of the spreadsheet analysis.

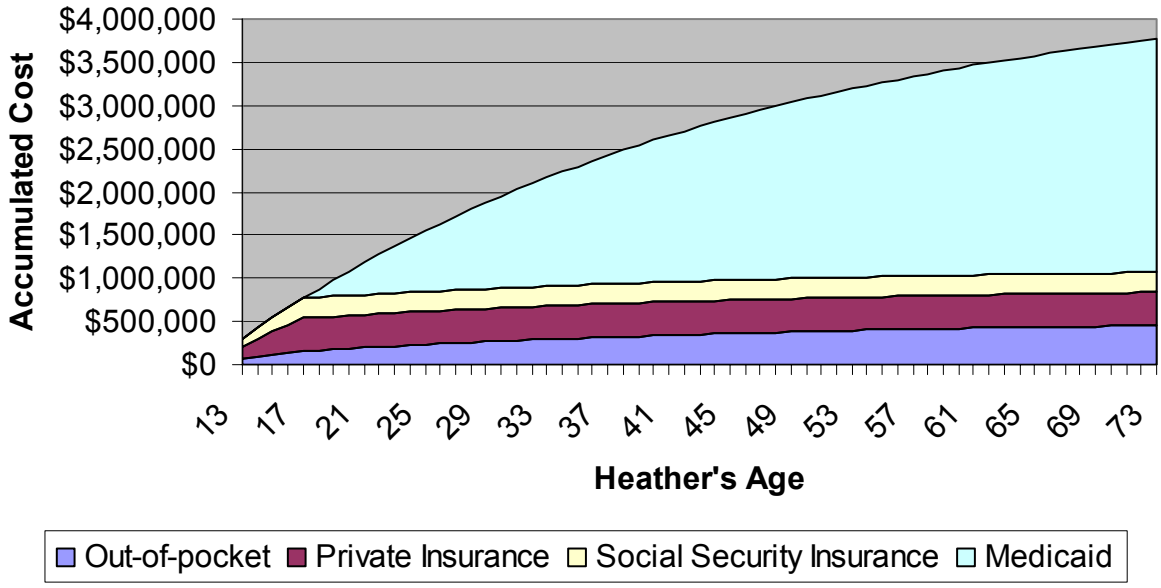
Sound Advice throughout the Years

The Sound Advice throughout the Years is a narrative about a farmer who is exposed to different sources of noise through his life that resulted in his loss of hearing. The story leads to a tragedy of his backing a pickup over his granddaughter when he is unable to hear her screams or yells from a friend to stop. The incident involved two men who progressed through 39 years from teenagers to grandfathers. One wore hearing protection throughout his life and the other did not. The 39-year cost of the ear plugs could range from $546 to $1,950.The grandfather who failed to wear hearing protection did not hear warnings from his friend or his granddaughter as he backed up in his pickup and ran over his granddaughter. The students choose whether the victim survived or not. The cost to society if death was the result was $2,322,000; The cost to society if the grandchild survived with injuries was $762,000.

No Way to Meet a Neighbor

The No Way to Meet a Neighbor narrative involved a car passing a tractor that was towing a baler and wagon loaded with hay when the tractor made a left turn and the car crashed into the tractor. The incident resulted in the death of both the tractor and car driver. The intervention that would have reduced the risk was turn signals on the trailer at a cost of $200. The cost to society not counting pain and suffering was $3,680,000.

Figure 2. Direct Costs (Medical Care) Distribution --Present Value--



The cost-effectiveness of each narrative-driven analysis is shown in Table 2.

Table 2. The Population-based Cost-effectiveness (social cost savings) for Interventions Taught for Each Narrative

Kayles Difficult Decisions	Heather on Horseback	Sound Advice throughout the Years	No Way to Meet a Neighbor
$380,000 savings per injury averted	$411,000 per head injury averted	$261,000 savings per person for which hearing impairment is averted	$315,000 savings per injury averted

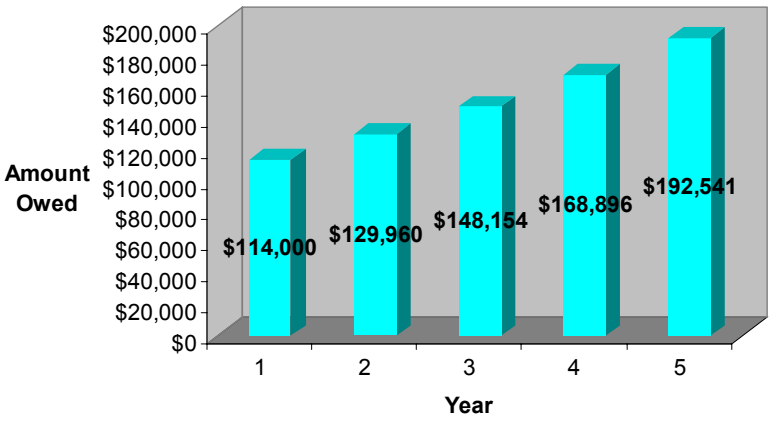
Discussion

The students in this study were most impressed by the cost to society as compared to the farm household perspective. They worked in teams of two to four, with each team comprised of high and low achievers, which worked well. The students also could associate with many of the

events such as tractor overturns in one county where the event occurred, the impact of noise upon hearing, and the problems of roadway collisions.

Many students were unacquainted with farming, so the exercise regarding tractor overturns was relevant to only a few of the students. In addition, the narrative portion of that exercise was longer that the other narratives, making it difficult to complete the exercise within a three day, 90 minutes per day time period. This exercise, however, is relevant to engineering students, and a shortened narrative step for their use may be necessary. Students should be given an option in the Heather on Horseback exercise for substituting an all-terrain vehicle for which many were more acquainted.

Figure 3. The Amount of Money Owed by Dan if He Paid Nothing on his Loan for 5 Years



Two train-the-trainer sessions were convened per year plus another meeting for review at the end of each year. The teachers appreciated the curricula that provided for them and the instruction in its application. They lacked material for teaching economics, and this curriculum filled that need while also teaching about injuries and their costs. An ancillary effect of this study was to teach spreadsheet skills and the potential for spreadsheet programming on Excel.

A curriculum using the cost analysis for agricultural and biological engineering education would have value for these students in their later employment or practice. As a design engineer, they would better understand the implications of designing defects out of products. As an engineer involved in business operations, they could bring to bear cost arguments to assure investments into safer operations, especially where there is a reluctance to invest in safety. Indeed, the analysis could be expanded to into a profit margin analysis to show the implications upon the additional revenue needed to balance the potential costs involved in injury events.

Conclusion

Safety stories in the teaching of economics provides relevance of economics, narratives aids in the memory of the lesson and in changing attitudes of the students, and a large amount of economic and safety concepts can be taught in small amount of time using the narrative-driven and multimedia (verbal instruction—both oral and written—and spreadsheet software with active graphics embedded in the worksheets) approaches.

Further research is needed in the general application and acceptance of this approach. The “Kayles Difficult Decision” narrative needs to be shortened for the first step of the curriculum to provide more classroom time for the latter three steps. Adding the revenue side of economics needs to be explored in addition to using the cost analysis approach. Cost can be used to demonstrate the impact upon profit through profit-margin analysis and thus the revenue to needed to replace the cost incurred because of the risk of injuries. To broaden its application, the narrative regarding Heath on Horseback needs to provide the option driving an all-terrain vehicle.

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