Insurance and Mathematics: Developing Democratic Citizenship Through Interdisciplinary Approaches to Contemporary Issues

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Insurance is an interesting interdisciplinary topic that can offer generative meaning and relevance for students. By adapting real life examples and authentic simulations, mathematical concepts can be applied to insurance-related social studies issues and content. This article explores ways to teach insurance and related mathematical concepts to middle school students using an interdisciplinary approach and it demonstrates various concomitant benefits in teaching mathematics with the concept of insurance by connecting it to important democratic citizenship dispositions such as civic participation, critical thinking, interpersonal skills, and knowledge of political activity. The ultimate goal of this interdisciplinary approach is to develop students' ability to make informed and reasoned decisions as current and future consumer-citizens.

Keywords: mathematics, social studies, insurance, citizenship education

Social studies education is one of the primary vehicles for educating and preparing future citizens who can actively participate in and promote democratic beliefs and actions. Yet, a growing number of recent studies (Barton & Levstik, 2004; Doppen, Misco, & Patterson, 2008; Heafner, Lipscomb, & Rock, 2006; Misco, Patterson, & Doppen, 2011; Rock et al., 2006; Torney-Purta, Lehman, Oswald, & Schulz, 2001; VanFossen, 2005) have suggested that social studies education is more frequently marginalized than other subject areas within the context of high-stakes testing that often privileges reading, writing, and mathematics.

Teachers face numerous challenges in offering relevant and meaningful social studies for their students. This is due in part to the conflicting cultures of education that are often encountered by social studies teachers. Many teachers tend to experience a discrepancy between what they learned in their university's teacher education program and what they teach in public schools. In short, social studies teachers frequently consider the idealistic approaches of the university that do not always align with the reality in classrooms where test-driven teaching plans and strategies are oftentimes emphasized (Apple, 2001; Au, 2007; Darling-Hammond, 2010; Leming, 1989). Due to this reason, many teachers simply offer textbook-based teaching that focuses on recitation and memorization with few opportunities for deliberation, reflection, reasoning, and critical thinking (Kahne, Rodriquez, Smith, & Thiede, 2000). As a result, students oftentimes perceive

historical content as detached from and irreverent to their current interests, concerns, and problems, and therefore consistently devalue social studies over many other subjects (Chiodo & Byford, 2004; Schug, Todd, & Berry, 1984).

Given these challenges, this article looks to mathematics, which enjoys a privileged place in the macrocurriculum, to broach social studies. Specifically, this article explores how to teach mathematics to middle school students in relation to insurance, which is an interdisciplinary topic that can offer generative meaning and relevance for students. By adapting real life examples of insurance, teachers can utilize mathematical concepts and apply them to social studies by aiming at students' informed and reasoned decision-making process. Furthermore, the practice of insuring and the American institution of insurance represent a contemporary controversial issue within the socio-political contexts of post-Katrina and the ongoing health care reform debates. This article highlights various concomitant benefits in teaching mathematics with the concept of insurance by connecting it to important democratic citizenship dispositions, such as civic participation, critical thinking, interpersonal skills, and knowledge of political activity.

Teacher Education and Interdisciplinary Approaches

Interdisciplinary approaches to teaching and learning broaden student knowledge of history and culture while increasing content understanding, raising test scores, enhancing critical thinking, enhancing ownership in the learning process, and developing life-long learning skills and dispositions (Duerr, 2008; Jones, 2009; Taylor, 2008). In teacher education, employing interdisciplinary approaches and epistemologies help prepare future teachers for 21st century global and local issues that require different kinds of learning (Gal, 2011). Teacher education faces a timely charge to reorganize disciplines through coordinated interdisciplinary education for all students (Kaufman & Brooks, 1996) and interdisciplinary teacher education focuses on new approaches to solve problems, promote dialogue, cinch together the interests of diverse stakeholders, and synthesize heretofore disparate ways of knowing how to prepare future teachers to take interdisciplinary approaches in their future classrooms (Klein, 2002; LaFever, 2008).

Social studies is a unique area of teacher education, one that is necessarily dependent upon an interdisciplinary curricular approach. Academic disciplines housed within social studies (e.g., history, economics, geography, political science, sociology, anthropology, psychology, and philosophy) are not only interrelated, but are most potent for democratic citizenship education when they are unified toward a specific problem or issue. In isolation, these disciplines offer the potential for epistemological pathways to understanding the world and the nature of different forms of knowledge. But in their unity, and directed toward student understanding of relevant, value-based, and normative issues, they contain the content necessary for students to make informed and reasoned decisions as democratic citizens (NCSS, 2010). Joining these disciplines with mathematics further expands the extent to which citizens are able to grapple and respond to real-life concerns and work toward developing a more just and sustainable society for all of its members.

Insurance and Social Studies from a Western Socio-Historical Perspective

The concept of insurance originated within the merchant guild of long-distance marine trade in medieval Europe (Gelderblom & Grafe, 2010; Supple, 1970). Later, fire insurance became prominent, most notably after the Great London Fire of 1666 (Nelli, 1976). Eventually, the underwriting of ships through analysis of variables became systematized at Lloyd's Coffee House, including descriptions of property, crew, and amount of insurance needed (Vance, 1911).

In the United States, the first insurance office opened near Penn's Landing in 1721. As the development of trade unfolded, especially during the 18th Century, being able to assuage risk ultimately encouraged investment, trade, commerce, and other acts of interchange that would normally require an extraordinarily high tolerance for catastrophe (Wertheimer, 2006). By no longer having to worry about being overleveraged and exposed to calamitous outcomes, entrepreneurs and citizens alike began to take calculated risks that enabled the building of factories, purchase of homes, and shipment of goods. Today risk can be mitigated for innumerable concerns, such as mortgages, crops, accidental death, long-term care, floods, travel, wages, disability, and scores of other possible phenomena.

Discussions about insurance are often focused mostly on one purpose—protection of individual property. Even though such protection is a major function of insurance in contemporary society, the insurance system rarely had a singular purpose. For instance, merchant guilds initially aimed to help each other in case of unexpected natural calamities and "personal hardship" among merchants (Gelderblom & Grafe, 2010, p. 6). In addition, insurance had to do more with strong social ties and relationships, which led the merchants to use it for collective protection (Gelderblom & Grafe, 2010). Insurance allows for an extension of Lockean ideals, most notably as a means to safeguarding property (Burke, 1995). In this sense, both insurance and the government work to secure individual rights, liberties, and property. As our democratic government began to offer public forms of insurance, the normative question arose concerning the onus of responsibility—the government or the individual. Just as a government could not deprive citizens of personal property (as later embodied in our constitution), neither could disaster, theft, and the vagaries of nascent globalization. Specially, the 5th Amendment to the U.S. Constitution guarantees that citizens will not be "deprived of life, liberty, or property, without due process of law; nor shall private property be taken for public use without just compensation." From this perspective, insurance is an extension of that guarantee within a more economic and public sphere.

Another example involves differentiating fire insurance and catastrophic relief. Originally, the people subscribing to insurance enjoyed the benefits of fire extinguishment and later replacement of loss, whereas those who did not have insurance ran the risk of losing property. Given the risk associated with the fire of one affecting many, it made sense to guarantee the extinguishment component of fire insurance to all members of a community through fire departments. As it moved into a socially shared responsibility sphere and usufruct, insurance entered a governmental system of taxation and spending. When communities are faced with a catastrophic flood, for which few may hold insurance, the government might call forth a state of emergency, thereby offering public resources to remedy a large-scale disaster, as in the case of Hurricane Katrina.

Because the concept of insurance requires planning preceding the event, to cover a risk *before the fact*, the issuance of insurance is also connected to economic equity and justice. For individuals living in poverty stricken communities who cannot afford to assuage risk by purchasing insurance (or who would choose not to procure the proper insurances for their property with contempt for nature), they would be unprepared for a disaster. People without insurance would simply endure the pains of loss regardless of lacking the resources to do so or the reflection on possible consequences. If we only consider insurance in light of the concept of deservedness, we would neglect one of the important purposes that insurance originally had— i.e., establishing a secure community and society where every citizen can be protected through mutual help. In one sense, ensuring each individual's security is situated both in public and private domains where a larger network of others taking on risk, especially those who did not afford to plan, is distinct from distributive justice models seeking to secure losses of individuals who had an a priori plan for risk.

The Mathematics of Insurance and Actuarial Science

The history and normative judgments about insurance can provide an opportunity for students to learn about the mathematics that underlies actuarial science. Teaching the concept of insurance in integrated lessons with mathematics and social studies brings a real world situation into the classroom, which can help students become more aware of how these combined subjects can relate to their lives. In addition to developing mathematical skills, this integrated teaching encourages students to become wise consumers and decision makers.

Teaching about insurance can effectively be connected to mathematical concepts by estimating actual insurance premium rates. Actuaries use mathematics, statistics, and tables (based on previous years data of a particular phenomenon) to make predictions about risk analysis and the financial costs of risks. However, constructing and using tables requires the ability to recognize and analyze trends for insurance firms to be profitable. Insurance involves a contract:

> . . . by the insurer to indemnify the insured against loss by the casualty defined in the policy. The insured pays a sum certain for protection against an event, which may or may not occur during the life of the policy. The premium is calculated with respect to the average chance that the given event will ever occur. (Abbot, 1910, p. 119)

Actuarial science involves the analysis of risk and its financial outcomes. By employing mathematics, financial theory, and statistics, actuarial scientists study the uncertainty involved in future events (Purdue University, 2012).

To calculate an insurance premium rate, an actuarial price can be modeled with three values— E(S), k, and R. The premium rate is the sum of these three values, all of which do not include reference to investments. The premium is described in Equation 1 (see below) by the following actuarial price-setting formula derived by Briys and de Varenne (2001):

$$\mathbf{P} = E(S) + k + R$$

In this equation, $\mathbf{P}$ represents the premium, or how much is being paid by the insured. Meanwhile, the function $\mathbf{E(S)}$ represents the mathematical expectation of claims for which

premiums increase as expected claims increase. This part of the equation assures that increased costs to the insurance company are passed along to the consumer(s). The **k** denotes ongoing company running costs (otherwise known as overhead) and **R** is a risk premium, which is the payment for coverage of unforeseen deviations (spikes) in the claims amount (Briys & de Varenne, 2001). As a safety factor, the **R** also insures the company's base profits to protect the company from massive losses when claim payouts are incurred.

Simulation Examples

To help students understand the mathematics behind insurance, we conceptualized the following simulations as a framework for developing multiple lessons with an interdisciplinary focus linking mathematics and social studies.

Example 1

This simulation describes how "Pencil Insurance" may work and how it might be included in a probability unit in mathematics or a justice-oriented unit in social studies. To begin, ask students to: (1) keep a record of how many times two fellow classmates forgot to bring a pen or pencil to classes throughout the day, and (2) record the specific class in which the pencil was missing. This should be done over several days, perhaps three to five days to establish a baseline. Using the data the students gathered, create a reference table (see Table 1 which shows "sample data" denoting the total occurrences of a forgotten pencil by class into probabilities).

Table 1

Sample Data for Probability of Forgetting a Pen/Pencil

Class Period	# of Times Forgotten					
	1	2	3	4	5	6
1	0.50	0.00	0.00	0.00	0.00	0.00
2	0.35	0.65	0.00	0.00	0.00	0.00
3	0.32	0.50	0.70	0.00	0.00	0.00
4	0.27	0.46	0.60	0.75	0.00	0.00
5	0.23	0.40	0.50	0.70	0.80	0.00
6	0.20	0.38	0.40	0.55	0.80	0.99

Note: The values are probability values for students forgetting a writing utensil based on the total observations for all students

This table shows individual class periods, but could also be based on days of the week. Formulating a table such as this provides an opportunity for students to broach issues about probability and chance. Students could calculate the probability for which their designated

classmate will forget his/her pencil for each class (based on the units of your table) using the formula in Equation 2:

$$P(\textit{Student}) = \frac{\text{Total times student does not have pencil}}{\text{Total classes observed}}$$

Similarly, the students can calculate the chance of any one of their classmates forgetting a pencil using Equation 3:

$$P(\textit{Class}) = \frac{\text{Total times any student does not have pencil}}{\text{Total classes observed}}$$

In Equation 1, a student's **P** or premium (their cost for the use of a pencil) would increase as the number of pencils that they forget increases. Economically, it costs much more to insure a student who forgets a large number of pencils, so in practice, they must pay more. The student's risk could be evaluated against the class standard, which is calculated in Equation 3.

In reality, students are creating a comparison between themselves and the class, akin to the mathematical expectation of claims and safety factor as shown in Equation 1. In this case, "higher risk" students, who forget to bring a writing utensil (i.e., pencil or pen) to class more often than the average, may be required to pay a higher premium to insure that they will not be without a pencil, as there is a greater probability that they will forget.

For this activity, position students to work in small groups to look for trends in the data they collect and have them create their own insurance plans. One suggestion is that all students pay a penny per class for insurance, which would provide a pen or pencil on loan for the class period. However, students who have a higher risk of forgetting their pencil will have to pay two pennies per class. The students could be given the option to consider if rates should increase after a student forgets their pencil or if they should have a fixed rate. As a class, discuss the insurance plan of each group and whether everyone thinks the plans are fair for everyone or only some. Also, consider whether pencil insurance should be a private enterprise run by a group of entrepreneurial students or if the risk of not having a writing utensil is so profound that the government (i.e., the classroom teacher) should provide pencil insurance for all students without cost.

Example 2

This simulation addresses the societal problems of using insurance inappropriately, whereby the risk that it is insured against is an inevitable outcome for all. In these situations, rather than employing or retaining insurance, students are asked to ponder the extent to which the public should provide risk mitigation for all in the form of usufruct. For example, all human beings are physically fallible and will, at some point, require medical treatment. The application of insurance to this particular phenomenon might therefore seem misguided given its inevitability. Rather than generationally engage in a national debate about health insurance and the government's role in providing insurance, perhaps we should accept the idea of free medical treatment for all, paid for by all citizens through taxation.

Because some citizens require medical treatment more often and at a greater expense than others because of lifestyle choices, some citizens may argue that they are being penalized financially for the poor choices of other citizens, whereas others may suggest that certain medical procedures are not needed due to cost, remaining life expectancy of the patient, among other variables. In short, providing treatment to all through shared responsibility seems appealing given the *purpose* of insurance, but given the many variables affecting each individual and their cost to society, it may unfairly burden those who make responsible health decisions.

In response to this normative policy problem, students can apply the lessons learned in the pencil insurance simulation to a new arrangement of variables. First, ask students to imagine a society of which they are not currently a member and consider what the most just system would be relative to health treatment and insurance. Similar to the "veil of ignorance" (Rawls, 1971), students are asked to consider justice and moral issues independent of their present station in life. Using the instructional strategy "powers of two," organize students in pairs and ask them to agree upon a system that should be in place and the ways in which the system should provide the greatest degree of justice, based upon whichever variant they choose (e.g., distributive, procedural, equalitarian). Keep amassing pairs of students into groups of four, then eight, and ultimately the whole class, while each time requiring a compromise in terms of what the just system should be for all class members.

Afterwards, construct a series of biographical cards indicating a wide variation of life choices, habits, genetic ailments, occupations, family history of disease, and other variables. These cards may also include the expected number of doctor and hospital visits over a lifetime, life expectancy, injuries, and other relevant material. Each student will take on the fictitious role and reconcile it with the negotiated system. Ask pairs of students to reflect and share their perspectives about the extent to which the system offered a just solution to their medical needs and whether it appropriately balances individual freedom with social responsibility.

Benefits of Teaching Mathematics and Social Studies with the Concept of Insurance

The benefits in teaching mathematics and social studies with the concept of insurance are numerous. By coupling mathematics and insurance, students can recognize and come to understand important democratic citizenship dispositions such as civic participation, critical thinking, interpersonal skills, and knowledge of political activity. In addition, broaching this relevant, normative, and controversial topic helps develop core democratic dispositions (Misco & Shiveley, 2010).

The three categories of core democratic dispositions, which are open-mindedness, wholeheartedness, and responsibility (see Table 2), resonate with student understanding of insurance from mathematical and social studies perspectives. For example, rather than simply accepting prima facie ideological claims about insurance in the media, students can marshal their understanding of these concepts to contemporary and novel examples with greater dissent, curiosity, and tolerance. Again, as a result of understanding insurance in a citizenship context, students will have the occasion to employ dispositions related to wholeheartedness, including

individual responsibility for insuring themselves and their family pursuit of understanding limitations of policies and fortitude related to insurance required within the public sphere.

Table 2
Core Democratic Dispositions

Open-Mindedness	Wholeheartedness	Responsibility
Tolerance	Self-discipline	Justice
Skepticism	Individual Responsibility	Compassion
Embracing Ambiguity	Patience	Generosity
Dissent	Persistence	Work for common good
Rationality	Compromise	Honesty
Embracing Diversity	Love of perfection	Respect rights of others
Curiosity	Loyalty	Respect property of others
Sympathy	Pursuit	Benevolence
Experimentation	Frankness	Dignity of others
	Fortitude	Opportunity
		Democratic principles
		Rule of law
		Fundamental human rights

Finally, as a result of this interdisciplinary inquiry, students are positioned to consider fundamental democratic principles concerning their own responsibilities to themselves and others, the rights of others (nationally and globally), as well as the relationship of insurance to dignity, law, and property. In addition to the simulation exercises, teachers can incorporate other activities that encourage students to embark on an inquiry into the normative and often controversial terrain of insurance in contemporary life. Specifically, students can be guided and shown how to apply what they have learned through simulation to questions related to Hurricane Katrina and national health insurance. For example:

1. Hurricane Katrina was the largest single loss to the U.S. insurance industry ($41 billion), yet the industry also experienced record profits of $44 billion in 2005, $63 billion in 2006, and $61 billion in 2007 (AAJ, 2008; Powell, 2007). This general trajectory of profit prompted the American Association for Justice CEO Jon Haber to indicate:

   Insurance companies are making record profits while raising premiums, stiffing policyholders, and refusing insurance to those who need it most. Never has the industry taken in more and handed back less. Insurance CEOs have forgotten they have a duty to their policyholders, as well as shareholders (AAJ, 2008, para. 3).

   To what extent should the government regulate the insurance industry? Given the larger purpose of insurance, should we force insurance companies to be not-for-profit?

2. A recent court case involving an insurance claim from Hurricane Katrina reported there was confusion about water, wind, storm surges, and hurricanes. In this case, the company was attempting to disentangle whether the damage brought forth was primarily due to flood versus wind. In short, was the house that it destroyed very important? State Farm and other insurers covered damage from hurricane wind, but not water ($1 million State Farm, 2008).

   Is it legitimate to make this distinction? What criteria should be applied to determine the coverage decision?

3. Although the quality of American medical care is excellent, high health care costs dramatically exceed those of other developed nations. The average costs of health care for an individual is a significant problem, particularly to lower-and middle-income Americans (White House, 2012). To deal with this issue, the Obama administration passed a historic Patient Protection and Affordable Care Act (2010) into law, which created a health care system with more governmental direction that also extended health care coverage to millions of uninsured Americans.

   Should the U.S. government offer universal health care for all Americans? Whose money will the government use to pay for this? How can American medical care system support over 45 million uninsured Americans and avoid giving more financial burden to those who take their responsibilities of paying taxes and being healthy?

Final Thoughts

Both mathematics and social studies pedagogy courses have the mechanism to encourage preservice and inservice teachers to support constructivist techniques, where students generate their own knowledge rather than acquire this knowledge through traditional lecture methods. Insurance is a topic that easily fits within this approach as it calls upon a variety of teaching strategies that can meet the each student's unique needs in the classroom. The topic of insurance also provides an opportunity to teach about something that students will find relevant and meaningful that meets the content standards of both social studies and mathematics.

Integrating concepts that align themselves to other disciplines within the curriculum (in this case, social studies and mathematics) can enhance students' ability to think critically, synthesize their learning, and apply it to a range of situations within their lives. To this end, the careful planning and implementation of lessons that relate to multiple content areas with real life examples can afford students the opportunity to actualize their learning in meaningful ways. In this situation, teaching concepts of insurance that draws pedagogical engagement between mathematics and social studies to help students develop active citizenship encouraging them to not only evaluate an issue but also to apply it to normative and logical judgments about an issue in a practical and realistic way.

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