About 40% of college students graduate in liberal art majors that don't require a quantitative course. Many of these students need a quantitative course for graduation and take statistics or math for liberal arts. All too often they don't see how these courses relate to their lives. As educated citizens, liberal arts majors need to think critically about statistical information. Statistical literacy was designed to address this need. The W. M. Keck Foundation acknowledged the potential of statistical literacy in their $500,000 grant to Augsburg College "*to develop Statistical Literacy as an interdisciplinary curriculum in the liberal arts*." Over 50% of the students completing statistical literacy agreed that "all students should be required to take this course for graduation." As a result of feedback from 12 faculty observers, a textbook was developed and Capella University adopted statistical literacy as an on-line course.

From this, we learned that statistical literacy is very different from other quantitative courses, that quantitatively-trained faculty need faculty development to switch from teaching mathematics or statistics (deductive logic courses with right-wrong answers) to teaching statistical literacy (a critical thinking course where answers are more or less plausible) and to be able to teach statistical literacy with confidence and without undue course preparation.

The project goal is *"to provide faculty with a turn-key system for teaching statistical literacy*." This complete "ready to use" system includes educational materials and faculty development. Most of this will be web-based to allow reasonable cost national dissemination during and after this project.

This Statistical Literacy Turnkey System project has **intellectual merit**:
- It involves teaching statistical literacy – critical thinking about statistics – as a liberal art.
- It helps students see semantic relations (the percentage of men among smokers) in ordinary English.
- It helps quantitative faculty see what quantitative ideas are needed in everyday life.
- It helps quantitative faculty see how advanced quantitative reasoning can be taught without formulas.
- It helps link the quantitative disciplines with those that are more qualitative.

This Statistical Literacy Turnkey System project will have **broad impact**:
- It will expose math/stats faculty at two and four-year colleges to the idea of statistical literacy.
- It will graduate up to 20 math/stats faculty as being adequately trained to teach statistical literacy.
- It will result in a turnkey system which will facilitate faculty development on a national scale.
- It will set the stage for the rapid dissemination of statistical literacy – and the means of teaching it.
- It will help students in non-quantitative majors think more clearly about numbers in the news.

This project builds on the STEM knowledge-base involving statistics and quantitative literacy.

This project is innovative in trying to help quantitative faculty teach the type of critical thinking commonly taught in the humanities. Dr. Schield, the Project Director of the W. M. Keck Statistical Literacy Project, is the Principal Investigator (PI). Author Joel Best described him as "*the movement's leading voice*." Although the web has been used to deliver course materials, this project uses the web for faculty development. But, it is well grounded – it is based on over four years of intense exploratory work.

This proposal addresses diversity by focusing on a large group of students that are sometimes ignored in STEM projects – students in majors that do not require a math course.

Project assessment will be conducted on two groups. The 100 students who take statistical literacy during this grant will review the adequacy of the new and enhanced web-based drill programs. The 24 faculty participating in the web-based faculty development will evaluate the adequacy of this statistical literacy turnkey system: the adequacy of the textbook, teaching materials web-based drills and their training.

A nationally-known educator will review the aforementioned evaluations and evaluate the suitability of this statistical literacy turnkey system for national deployment. The Principal Investigator will conduct formative assessments. A project evaluator will conduct a summative assessment of the entire project.

Project Goal:

The project goal is *"to provide faculty with a turn-key system for teaching statistical literacy."*

Statistical literacy is designed for liberal arts majors: students in majors that don't require a quantitative course. It is designed to help them be better citizens, to analyze the use of statistics in the news.

This view of statistical literacy fits in with Dr. David Moore's view. He distinguished *statistical literacy*[1] ("What every educated person should know about statistical thinking") from *statistical competence*[2] ("roughly the content of a first course for those who must deal with data in their work" or "what we hope a statistics student will retain five years later"). See Schield (2004b).

In talking about statistics and quantitative literacy, Lynn Steen (2004) noted,
> *"In reality, data analysis -- what most statisticians actually practice -- is typically more than the average person needs to be an informed citizen, intelligent consumer or skilled worker. What everyone needs is typically called statistical thinking or statistical literacy, a crucial component of quantitative literacy." p. 43*

In "*More Damned Lies and Statistics*," Joel Best (2004) titled his last chapter, "*Toward Statistical Literacy?*" Dr. Best questioned whether statistical educators will take responsibility for this area. Dr. Richard Scheaffer in talking about Quantitative Literacy argued that statistics could and should.
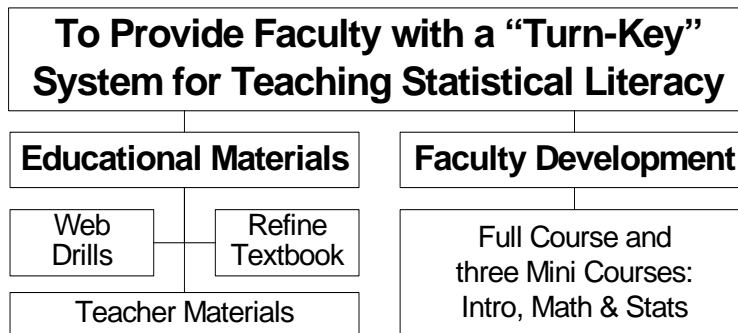> "*Some of the QL leaders tend to see statistics as only the small part of QL that deals with chance. I see statistics as much broader than that; in fact, I see it as encompassing much of the QL litany of topics that deal with data and its practical use in everyday situations. Thus, there is an important role for statisticians to play in this expanding interest in QL.… Statistics is the branch of the mathematical sciences that deals with numbers in context – data – and makes systematic study of how to reason under uncertainty. Statistics must be a key part of QL!*" "*Over the years, statistics has lost out on many initiatives that should have been its province because of lack of interest or lack of foresight. Isn't it time we wholeheartedly embrace one that we can see coming?*" See Schield (2004b).

Statistical literacy overlaps nicely with the quantitative literacy of Lynn Steen and the statistical thinking of Richard Schaeffer.

The project goal is *"to provide faculty with a turn-key system for teaching statistical literacy."*

To train faculty to teach statistical literacy quickly and on a national scale requires a "turnkey" system. A turnkey operation has been defined as "A product or service which can be implemented or utilized with no additional work required by the buyer (just by 'turning the key')". A franchise is a classic example. Buying a franchise may still require education and it certainly requires work to hire and train the right people, but the franchise offers the information needed: the package is complete.

Creating a turnkey system for faculty to teach statistical literacy involves two activities: Educational materials and Faculty Development.

Some of these items exist and will be refined. The textbook, quizzes and tests have been used by over a thousand students. A web-based drill program that reads ordinary English has been used by over a hundred students. Four of the seven textbook chapters are being taught on-line as a half-semester course.

Some of the items will be created. Additional web-based drill programs will help students practice new skills outside of class. A web-based faculty development program will enable interested faculty to experience the course, to learn what students find difficult and to be trained in using the web-based tools. Faculty development will be provided in modules allowing faculty to try one module first.

At the end of this project, all the elements will be in place for national dissemination using a "turn-key" system to prepare faculty to teach statistical literacy.

Statistical Literacy:

Since the goal of this project is to help teachers teach statistical literacy, the intellectual merit and the impact of this project depend largely on the intellectual merit and impact of statistical literacy. And that in turn depends on exactly what statistical literacy is.

Statistical literacy is an interdisciplinary curriculum for students in non-quantitative majors. Statistical literacy includes elements of mathematics, statistics, epidemiology and critical thinking.

Mathematical elements of statistical literacy include:

- Arithmetic (6 is 3 times as much as 2, 6 is 200% more than 2, 6 is 3 times more than 2) but the focus is on how arithmetic comparisons are expressed in ordinary English.

- Fractions and percents (10% of women are runners, 10% is the percentage of women who are runners, 10% is the percentage of runners among women) but the focus is on understanding such expressions. Many students mistakenly conclude this means that "10% of runners are women."

- Comparisons of ratios ("Widows are more likely among those who commit suicide than are widowers," but "widowers are more likely to commit suicide than are widows") using ordinary English.

- Bayes Rule Applications: Bayes rule states that $P(B|A)P(A) = P(A|B)P(B) = P(A \cap B)$. If $P(A)$ is much different from $P(B)$, then $P(A|B)$ is much different from $P(B|A)$. This shows up in medical tests. A test with a 95% accuracy, $P(\text{positive}|\text{disease})$, may have only a 50% accuracy in prediction, $P(\text{disease}|\text{positive})$. The misuse of Bayes Rule shows up in informal reasoning. If most CEOs had a pet as a child, statistically illiterate readers may mistakenly conclude that having a pet for their child substantially increases their child's chance of being a CEO but in so doing they are presuming that CEO's were more likely to have had a pet than were non-CEOs.

- Bayes Rule Comparison: This states that $P(B|A)/P(B) = P(A|B)/P(A)$. For example, if people with low IQ are 5 times as likely among those in prison as among those in the population, then it follows that people with low IQ are 5 times as likely to be in prison as are those in the general population. This reasoning is commonly presented using graphs showing the percentage of an outcome in a population subgroup and in the entire population. See Schield and Burnham (2002)

- Weighted averages (The best hospital in the state may have the highest death rate even though it has the lowest death rate among both groups of patients: those who walk in and those who are carried in.) From a mathematical perspective, the fact that an association can change in size and direction after taking into account the influence of a confounder is simply an instance of the difference between a total and a partial derivative. But most liberal arts majors will never take a course on differential equations. Yet they need to understand this distinction to understand how statistical associations can change depending on what is controlled for.

Statistical elements in statistical literacy include items from introductory statistics, from probability theory and from the second course on multivariate regression:

- Error or bias (all the elements commonly taught in introductory statistics)

- Conditional probability: $P(BC|A) < P(C|AB)$. E.g, The percentage of high school students who dropped out because of boredom is less than the percentage of high school dropouts who were bored."

- Coincidence and chance. A heavy focus on how the unlikely becomes more likely than not given enough trials. Picking out amazing coincidences after the fact (winning the lottery twice) can be seen as something that is expected given enough trials. See Schield (2005b).

- Statistical confidence: Random error, sampling distributions and sampling error (that are common in traditional statistics) appear infrequently in the everyday news, so little time is spent on seeing how they are formed. Margin of error and confidence intervals are accepted as given. Statistical significance in association is taught in terms of non-overlapping confidence intervals. See Schield (2004b).

- Bayesian statistics. Since being "statistically significant" is often said of things that are extremely unlikely (e.g., ESP, psycho-kinetic powers, etc.) a Bayesian view of Frequentist hypothesis tests is introduced: the less likely the truth of the alternate prior to the study, the smaller the p-value required from the study in order to justify rejecting the null and accepting the alternative. See Schield (2005b).

- Confounder influence on statistical significance: All too many students completing introductory statistics conclude that if an association is statistically significant then that is an immutable fact. Students studying statistical literacy actually work out problems to see whether controlling for a related factor by means of standardization can transform a statistically significant relationship into one that is statistically insignificant – or vice versa. See Schield (2004b).

Epidemiological elements include:

- Studies and confounders: experiments vs. observational studies, longitudinal vs. cross sectional. Randomized assignment eliminates pre-existing confounders. Cross-sectional observational studies can not be influenced by time-varying confounders; longitudinal observational studies (before/after) cannot be influenced by cross-sectional confounders (involving other groups)

- Double ratios: A focus on relative risk and percentage attributable to a factor in place of correlation. Even if a high percentage of an association is attributable to some factor and even if this difference is extremely unlikely if due to chance, this association may still be due to a confounder: a related factor not taken into account.

- Standardization: This is commonly used in demography in adjusting for differences in age distributions in populations; it was a more common technique before computing made multivariate regression so easy. This technique is used to show students what it means to "take into account" the influence of a related factor. See Schield (2006b).

- Spurious associations and Simpson's paradox. What are the necessary conditions for an association to become spurious or to reverse after taking into account the influence of a third factor? Even though necessary conditions are weaker than sufficient conditions, necessary conditions are often simpler and easier to remember. In Schield and Burnham (2003) "defining conditions are obtained under which a binary confounder will nullify (render spurious) or reverse an association between binary variables when using a non-interactive (NI) linear OLS regression model. These defining conditions are used to derive necessary conditions for NI spuriosity and reversal. These necessary conditions include generalizations of those obtained by Cornfield and Gastwirth. Cornfield's "no effect" condition for spuriosity is found to be a special case of NI spuriosity. The reversal which occurs in Simpson's paradox is found to be a special case of NI reversal. Simple tests are obtained to

infer whether an association will be increased, decreased or reversed after controlling for a confounder."

Statistical literacy studies the application of epidemiological thinking to non-epidemiological problems such as real estate prices, school rankings and social conditions. The mathematics of standardization and nullification are what make statistical literacy different from mathematics and statistics.

Critical thinking elements include:

- Assembly. Assembly reflects Joel Best's thesis that "all statistics are socially constructed." **Assembly** is the art of defining and presenting ideas. Defining things is an art since people with motives can choose how to define things ("dysfunctional family," "hate crime" and "snow-related accident") It may be the choice of the mean or median; it may be the choice of "the percentage who are happy" vs. "the percentage who are unhappy." Presenting things is also an art. In comparing 4% with 2% we can say 100% more or 2 percentage points more.

- Hypothetical thinking: What factors could have explained the observed association? This is thinking outside the data – outside the box. This is seldom an issue in either mathematics or statistics. But it is central in thinking about how strong is the evidence for the truth of an inductive argument.

- Inductive reasoning: How strong is the evidence for saying that the observed statistical association is strong evidence for a generalization, a prediction or an explanation – a causal connection?

Putting all these seemingly disparate elements together into a single discipline requires an integrating principle. The integrating principle in statistical literacy is to understand all the influences on an arithmetic association. If women who drink green tea weigh less than those who don't, we still must "take care" before concluding that the green tea causes the difference in weight.

Statistical literacy says, "Take CARE" in using statistical associations as evidence for causal connections.

In "Take CARE", the four letters in CARE each signify a category of influences on a quantitative association. C stands for context or confounding: what we take into account influences the number. A stands for Assembly: how statistics are defined, measured and presented. R stands for Randomness which includes chance, statistical inference and the influence of a confounder on statistical significance. E stands for error or bias: subject bias, researcher bias, measurement bias, etc. For more on how statistical literacy is taught, see Isaacson (2005).

Readers use this simple four-factor framework to analyze the use of statistics in news stories. This framework integrates traditional mathematics/epidemiology (Context/confounding/multivariate regression), critical thinking (Assembly and hypothetical thinking) and statistics (Randomness and Error/Bias). Often these statistics are a single number or ratio (e.g., "30% of high school dropouts said school was boring"). Analyzing such statistics is very different from algebraic models or statistical inference.

This integration of mathematical, statistical, epidemiological and critical thinking is what makes statistical literacy so innovative. This integration is why many students find statistical literacy so very different from – and perhaps more relevant than – a traditional course in statistics. This integration is why college teachers need faculty development and why new educational materials are needed.

Project Background and Rationale:

BACKGROUND: In 1995, Dr. Schield began developing Statistical Literacy at the RSS Centre for Statistical Education in Nottingham England. In 1998, Augsburg College authorized Dr. Schield's Statistical Literacy course as an approved catalog course in General Studies (GST 200). This course was designed for students in the humanities: students in majors that didn't require a quantitative course as a prerequisite for their major. Since the goal was to help students be better citizens, statistical literacy

focuses on the use of statistics in the general news media. At the beginning of a course, few if any of the students would take it as an elective. After completing the course, over 50% thought that "all students should be required to take this course for graduation." In 2001, the W. M. Keck Foundation awarded Augsburg College a $500,000 grant "*to develop statistical literacy as an interdisciplinary curriculum in the liberal arts.*"

In 2002, Project Director Schield conducted the W. M. Keck Statistical Literacy survey of students, data professionals and teachers on three continents. In 2004, Dr. Schield was asked by the AACU's Peer Review to write "*Statistical Literacy and Liberal Education at Augsburg College.*" See Schield (2004a). He was invited to present "*Statistical Literacy Curriculum Design*" for an international roundtable on curriculum design by the International Association of Statistical Educators (IASE). See Schield (2004c). And in 2004 Capella University decided to adopt Schield's statistical literacy course for use on-line.

By the end of the Keck grant in 2005, a dozen faculty had observed the Statistical Literacy course at Augsburg and reviewed the materials, Peter Holmes and Joel Best had spoken at Augsburg and had reviewed some of the materials, and a textbook had been published. The textbook has been used by over a thousand students at Augsburg College and Capella University. Schield's Statistical Literacy website (www.StatLit.org) received 34,000 visits in 2005.

Even though the Keck grant ended in 2005, activity on statistical literacy has continued. In 2006 Dr. Schield was asked to prepare "*Presenting Confounding and Standardization Graphically*" for STATS magazine – a publication of the American Statistical Association (ASA). In the summer of 2006, Dr. Schield will be giving papers on the W. M. Keck Statistical Literacy survey in Ann Arbor for the International Association of Social Science Information Service and Technology (IASSIST) and in Brazil at the International Conference on Teaching Statistics (ICOTS). This survey highlights problems that students, quantitative analysts and college faculty have in reading tables or graphs of rates and percentages.

Statistical literacy is closely related to numeracy, quantitative literacy, quantitative reasoning and statistical thinking in that they all deal with the use of numbers by everyone on an everyday basis. Statistical literacy is distinct in that it focuses more on critical thinking and inductive arguments than on the traditional arithmetic manipulation skill-building exercises. With its focus on using statistical associations as evidence of causal connections, statistical literacy is quite distinct from the more formal approaches to quantity. This focus on causation has drawn praise.

- *There are few tasks in education today which are as urgent as improving the quality of Statistical literacy*," Dr. David Kelley, philosopher and author of "*The Art of Reasoning*."
- "*From my perspective, this teaching of causal inference is the most interesting topic today in statistical education, certainly so at the undergraduate level,*" Dr. Donald Rubin, Harvard University.

But feedback from professional statistical and mathematical educators indicates some resistance to this critical thinking approach to statistical literacy.

- Leading statistical educators were asked if students should be shown "*that statistical significance can be influenced by a confounder in all introductory statistics courses*?" In an anonymous survey, 15 agreed and one was indifferent. When these same people were asked, "*Should introductory statistics teach students more about confounding even if that means less time for statistical significance*?", seven agreed, four were indifferent/undecided while five disagreed. See Schield (2004c)

- Leaders in mathematics and statistics education identified the key elements in quantitative reasoning and statistical thinking. Context and confounding – key elements in statistical literacy – are not even on their lists so far. The social construction of statistics to support a non-statistical conclusion is not even on their list of possible candidates.   See Schield (2005b)

Nevertheless events seem to be overtaking the traditional approaches to statistical or quantitative appreciation. The increasing flood of statistical data from large observational studies (NAEP, NLSY,

Harvard Nurses Study, etc.) is increasing the need for statistical literacy among college graduates. Dr. Schield believes that the statistical literacy is well-positioned for continuing – if not explosive – growth.

Meanwhile there have been other approaches involving numeracy, quantitative reasoning or quantitative literacy. Although the NSF has funded projects that focus on teaching statistics to students in majors that require a quantitative course (e.g., AIMS, MAC^3, CAUSE, SCI and ARTIST) these projects did not focus on teaching quantitative reasoning to students in majors that don't require a quantitative course as a prerequisite. The NSF has funded a few projects that focus more on students who are not majoring in statistics. In 1990, the NSF funded the *Chance project*. According to the PI, Laurie Snell, that project did not result in a substantial change in teaching because it did not involve the production of teaching materials that allowed teachers to use articles from the general news media without extensive work on the part of the teachers. More recently, the NSF funded a project, Quantitative Methods for Public Policy, at Macalester. While this course was very popular, it was more of a topics course since it did not involve a textbook and it appears that Macalester College will not be continuing that course after the funding ends. Based on the results of these two projects, there is a need for a critical thinking course that involves a textbook that presents general principles yet helps teachers focus on current news stories.

Lynn Steen (2004) noted this problem, "*Earlier innovative, QL-type courses "had one thing in common that contributed to their remaining a small elective rather than a major requirement -- they were designed specifically to focus on ideas -- generally QL-like ideas -- rather than techniques. This made them more difficult for teachers to teach and for students to master, and for that reason they thrived only in special niches out of the mainstream of college mathematics*." p. 39 This is a major problem: how to teach ideas rather than techniques yet make it about as easy for teachers to teach and for students to master as a regular techniques course. That is what Schield's approach to Statistical Literacy tries to do.

Schield's approach to Statistical Literacy has a number of distinguishing characteristics. (1). Statistical literacy is centered in the inductive reasoning aspects of critical thinking where arguments are weak or strong, rather than on deductive reasoning where arguments are valid or invalid. (2) It focuses more on context and confounding than on chance, which makes it more relevant in a world where observational studies are more common than clinical trials. (3) It teaches conditional probability using ordinary English ("the percentage of men who are smokers" versus "the percentage of men among smokers.") (4) It uses a new graphical technique that allows students to calculate the change in an association that results from taking into account a confounder: a related factor that is tangled up with an association. (5) It presents statistical significance as the absence of overlap between two 95% confidence intervals. (6) It presents the influence of a confounder on a statistically significant association – something that is not presented in any other introductory statistics course or textbook. (7) It focuses more on the social construction of statistics than on context, chance and bias combined. (8) It does all this by focusing on arguments presented in the general news media. This allows the course to retain a freshness and spontaneity – a connection with current events – that is missing in most quantitative courses. (9) Finally, it provides the teacher with a standard template to use in the evaluation of a wide variety of arguments. This integration of permanence (the template) with variety (the current news essays) is what makes this critical thinking course teachable with minimal course preparation.

Bringing together all these new ideas into a textbook that is "usable by students and useful to faculty" has been a major goal of the W. M. Keck Statistical Literacy Project. During that project, Schield's Statistical Literacy textbook was extensively field tested by both students and faculty from a wide variety of disciplines. See www.StatLit.org/Schield.htm.

At the completion of the W. M. Keck Statistical Literacy project, the primary feedback from the 12 internal reviewers was that statistical literacy is very different from traditional statistics – or from any quantitative course. Statistical literacy focuses more on critical thinking than on algebra, more on words than numbers, more on induction than deduction, and more on strengths and weaknesses than on correct

or incorrect. Their conclusion was that teachers trained in mathematics or statistics will need much more training and support to be effective in teaching statistical literacy.

Work Plan

The project goal is *"to provide faculty with a turn-key system for teaching statistical literacy."* The proposed work plan is designed to achieve this goal. Effective faculty development requires a complete package that is well designed and has received positive review in field testing.

Faculty who participated in the W. M. Keck Statistical Literacy project and who observed the teaching of statistical literacy in the classroom were asked what they felt would be needed to develop faculty expertise among faculty at other schools who could not visit Augsburg and attend the classes. Their first point was that while observation was very helpful, participation was essential. Without participation, one was much less likely to see the connections between the arguments in the general news essays and the elements of the course, much less likely to see the difficulties involved in using ordinary English to describe and compare conditional probabilities, much less likely to see the value of using graphical techniques to describe how one takes into account the influence of a confounder, and much less likely to appreciate the value of the web-based drill programs in helping students use ordinary English to describe and compare rates and percentages as presented in tables and graphs. This work plan is based on their feedback.

The project goal is *"to provide faculty with a turn-key system for teaching statistical literacy."* That goal and the aforementioned feedback from previously-trained faculty are the basis for this work plan.

1. CREATE, REFINE AND DISSEMINATE EDUCATIONAL MATERIALS
    1a. Create a list of news articles that use statistics as evidence and index these for quick access.
    1b. Create a brochure introducing this faculty development
    1c Create web-based Power point with audio introducing web-based faculty development courses.
    1d. Refine the Statistical Literacy textbook for better readability.
    1e. Create a web-based drill program to help students describe ratios presented in tables and graphs.
    1f. Create a web-based drill program to help students analyze news articles involving statistics.
    1g. Analyze grammar of chance, incidence and prevalence for an ASA paper.
    1h. Extend the existing web-based drill program to read a greater variety of statements.
    1i. Analyze use of double ratios as evidence for causation for an ASA paper.

2. CREATE AND DELIVER FACULTY DEVELOPMENT
    2a. Create full web-based faculty development in Statistical Literacy using Moodle.
    2b. Conduct full faculty development session in summer to 6 faculty.
    2c. Conduct full faculty development session in fall to 12 faculty.
    2d. Conduct 3 mini faculty development sessions in spring to 6-12 faculty.
    2e. Analyze delivery of web-based faculty development for an ASA paper

Details on each of these will be presented later.

The web-based faculty development is structured in two versions: full and mini. The full version covers all 7 chapters of the Statistical Literacy textbook and takes 8 weeks. The mini-versions are as follows:

INTRO	3 weeks	Chapters 1 and 2 – which set the stage for the rest of the textbook.
STATS	3 weeks	Chapters 3 and 7 – which cover measurements and chance.
MATH	4 weeks	Chapters 4, 5 and 6 – which cover counts and ratios of counts.

Offering faculty development in smaller pieces may encourage more faculty to try out it out. They can complete the entire course (all 7 chapters) if they complete all three mini courses.

Personnel are an essential part of this project. Dr. Schield, the Project Director of the W. M. Keck Statistical Literacy Project at Augsburg College, is the Principal Investigator (PI) on this project. He

worked with Dr. Larry Copes, Marc Isaacson and Tom Burnham during the W. M. Keck Statistical Literacy grant. Dr. Larry Lesser is nationally known and respected in statistical literacy. Dr. Velma Lashbrook is an experienced project assessor.

Marketing is an essential part of this project. Dr. Schield will be responsible for creating statistical literacy brochures for prospective teachers of statistical literacy. These brochures will "advertise" this new turn-key system including faculty development. They will be distributed whenever Dr. Schield gives a talk whether at a conference for statisticians (ASA), for mathematicians (MAA), for the MAA Quantitative Literacy Special Interest Group (MAA QL SIG) or for the National Numeracy Network (NNN). He will also be responsible for creating a web-based Power-point presentation with audio that introduces the Statistical Literacy faculty development courses: the full course and the mini courses.

Research is an essential part of this project. To expand the current web-based drill program to handle additional grammars (chance, rates and relative risk), a paper is planned on the grammars of chance (odds, likelihood, risk and probability), rates (incidence and prevalence) and relative risk. Since statistical associations are used as evidence for causal connections, a paper is planned that evaluates the use of double-ratios (e.g., odds ratios, relative risk) as a sign of causal connections. See Schield and Burnham (2002).

Assessment is an essential part of this project. Dr. Schield is responsible for formative assessment. Dr. Lesser is responsible for evaluating how well this project has achieved its stated goal of creating a turnkey system. Dr. Lashbrook will be responsible for summative assessment of all aspects of the project.

Since one outcome is to improve web-based drill programs, students will be asked about these new or enhanced tools. Since another goal is the development of faculty expertise, the faculty participating in the full course will review the course goals, the textbook and the materials: exercises, quizzes, index of essays, the on-line drill programs, the web-based faculty-development course and the web-based discussion group. These reviews will be forwarded to the Project Reviewer who will prepare written reviews of the participant's assessments and comment on the ability of this project to be successful in national dissemination.

Selecting participants

As a member of the ASA Section on Statistical Education, the Principal Investigator will send an announcement to all the members of that section. As a member of the International Association of Statistical Educators, the Principal Investigator will send an announcement to all the members of that group and to all those attending the International Conference on Teaching Statistics. The PI will also send a notice to the 850 individuals who receive StatLit News.

Once the project is approved, opportunities for participation will be advertised and applications solicited. Finding participants does not seem like a big problem since several dozen faculty have already indicated interest in learning more about statistical literacy. Already 16 faculty are paying $75 each to attend a half-day workshop in Ann Arbor MI in May to hear the project PI talk about Statistical Literacy. At least 25 faculty have already indicated a strong interest in learning more about statistical literacy.

Applicants will be asked about their interest in teaching to liberal arts students and their ability to offer a statistical literacy course as either a new topics course or as a remake of a section in an existing course.

If applications exceed the number of paid slots, the applications will be forwarded to the external reviewer for guidance in making hard choices. Those who want to participate without receiving payment will be encouraged to do so – up to a maximum of 25 per web-based course.

Participants who complete the training with adequate scores and who submit their course evaluations will receive a certificate acknowledging their successful completion of this faculty development.

Project Review and Assessment

REVIEW: The project reviewer will review the feedback from the participants and evaluate to what extend this system if indeed a turnkey system: complete and ready to go. If time permits, this reviewer may participate in all or part of the on-line training in either the fall of 2007 or the spring of 2008. The reviewer will review the detailed project plans, the materials created under the project, the feedback received from the faculty participating in the project and the extent to which the project achieved its' stated goals. The reviewer will receive all their information by 15 May and will submit their written report to the PI by 25 June.

ASSESSMENT: At the start of the project, the Principal Investigator will prepare a plan to assess the entire project: to identify the planned surveys and questionnaires. The project evaluator will evaluate this plan and give helpful feedback. At the end of the project, the Principal Investigator will send copies of the feedback from the students and the teacher-participants to the project reviewer for his evaluation of the degree to which this project has produced a turnkey system for use by future faculty and to the Project Evaluator for her evaluation of the entire project.

The Textbook

The viability of this project is dependent upon the adequacy of the textbook. It takes a long time for a discipline to hone a new topic or teaching technique. And while this text has been in process for many years and has been used by over a thousand students, it involves so many new topics, that it can not be viewed as a final product. Here are the contents:

TABLE OF CONTENTS   See www.StatLit.org/Schield.htm for further detail.

Introduction
Chapter 1: The Story behind the Statistics
Chapter 2: Take CARE
Chapter 3: Understanding Measurements
Chapter 4: Describing Ratios
Chapter 5: Comparing Ratios
Chapter 6: Understanding Ratios
Chapter 7: Understanding Chance

Work Plan Details Organized by the Individual Responsible

Recall the work plan mentioned previously.

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　　1h. Extend the existing web-based drill program to read a greater variety of statements.
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　　2b. Conduct full faculty development session in summer to 6 faculty.
　　2c. Conduct full faculty development session in fall to 12 faculty.
　　2d. Conduct 3 mini faculty development sessions in spring to 6 faculty.

2e. Analyze delivery of web-based faculty development for an ASA paper

Here are the details on each activity organized under the individual responsible for that task.

Dr. Milo Schield, the Principal Investigator, has these tasks:

1a. Create a web-based list of news articles indexed by salient characteristics by June 2007. The availability of this list will help teachers find news articles that illustrate a particular aspect of statistical literacy with little effort on the part of the teacher. Salient characteristics include the type of study (experiment vs. observational, cross-sectional vs. longitudinal) the kind of statistics (counts, measures or ratios), whether or not any factors were taken into account, etc.

1b. Create a brochure describing this faculty development effort. Complete by June 2007.

1c. Create a web-based Power Point demo with audio by June 2007 that informs interested faculty of the opportunities for participation in this grant and the various levels available. The goal is to attract faculty interested in statistical literacy, to educate them on the nature of and need for statistical literacy and to encourage them to sign up for the faculty development courses offered under this grant.

2c. Moderate a full web-based statistical-literacy faculty-development course for the grant participants in the fall of 2007. This will cover the entire text.   During this course, faculty will be exposed to the problems that students have in analyzing essays, in describing and comparing rates and percentages presented in tables and graphs, in taking into account the influence of a confounder on an association and on statistical significance. Schield and Isaacson have both completed the Capella training for being an on-line course moderator, so both are qualified for this responsibility. Generate a formative assessment of strengths and weaknesses.

2d. Moderate three mini web-based statistical-literacy faculty-development courses for the grant participants in the spring of 2008. These mini courses cover just parts of the text.   Generate a formative assessment of strengths and weaknesses.

Manage the project, attract participants, oversee the work plan, design assessment surveys, conduct formative assessments and summarize the project results.

Marc Isaacson, a seasoned developer of on-line courses, has these tasks:

2a Design web-based faculty development courses in statistical literacy using Moodle. Since this course is so different from other quantitative courses, the goal is for faculty to experience the course as would the students. Since this is not possible, the faculty will experience the course, do the exercises, take quizzes and evaluate news articles. Since they are faculty rather than students, there will be a separate set of discussion questions on the choice of topics and the design of textbook.
Content: This course will have the same form as the Statistical Literacy course that Isaacson developed for Capella University. It will cover all seven chapters of the statistical literacy textbook. This task includes the appropriate documentation of learning objectives and the integration of assignments. This course must be designed so it can be delivered as a full course or as three separate mini courses.
Timing: This program must be ready to use by May 2007 for testing with the first group of faculty in the summer. Based on their, the system will be updated before use in the fall. Based on feedback from the faculty participants in the fall, the full course and the three mini courses will be updated by the end of December for use in 2008. The entire set of courses will be updated again based on the feedback from the spring group of faculty participants.

2b. Moderate a full web-based statistical-literacy faculty-development course for the grant participants in the summer of 2007.   Faculty will be selected in the proximity of Minneapolis. This will allow a

face-to-face focus group at the end of this course that may uncover suggested improvements for the fall course. This full course will cover all seven chapters of the statistical literacy textbook.

2e. Prepare a draft of a paper by June 2008 for presentation at the American Statistical Association on the design of this web-based course and on the response from the participants.

Dr. Larry Copes – a seasoned mathematics educator, the editor of a number of quantitatively-based textbooks and the editor of the Statistical Literacy textbook – has the following tasks.

1d   Complete an in-depth edit of chapter 7 in the textbook to improve readability and comprehension. Complete a lighter integrative edit of the entire text.   These must be completed by April 2007 so the textbook can be printed for use by all participants during the grant period.

Tom Burnham, Cognitive Consulting in San Antonio, has the following tasks:

Tom has major responsibilities under this grant proposal. He has performed well in accomplishing similar tasks under the W. M. Keck Statistical Literacy grant. Under that grant, he created a unique web based program that decodes a student's ordinary English descriptions and comparisons of rates and percentages as presented in tables and graphs. Not only does this program "read" ordinary English, but it gives helpful feedback on student misuses of ordinary English. Students have found the unique web-based drill program extremely helpful. See his Biosketch for a reference to the article summarizing the nature of this program and the student responses.

Tom will be responsible for the following:

1e. Create a new web-based drill program to help students drill on identifying the part and whole in a ratio (rate or percentage) when presented in a statement, graph or table. It will allow an administrator to edit existing problems and add new problems without changing the program. This program will capture student choices and comments. Detailed specifications have been prepared by Schield, reviewed by Burnham, and are the basis for the time estimate.
Content: Dr. Schield will be responsible for generating final program specifications by January 7. These specs will elaborate on the preliminary specifications that have already been provided.
Timing: The program must be completed by the end of February 2007 for immediate testing by Augsburg students in Spring Day School. Students who just completed the Statistical Literacy course identified this as the biggest weakness in the existing program from their viewpoint.

1f. Create a new web-based drill program to help students drill on evaluating news articles using the essay evaluation form. It will allow an administrator to edit existing problems and add new problems without changing the program. This program will capture student choices and comments. General specifications for this program have been discussed with Burnham and are the basis for this estimate.
Timing: Dr. Schield will generate program specifications by January 15, 2007. The program must be completed by April 30 for testing by Augsburg students in Spring Weekend College.

1g. Analyze the grammar of chance (risk, odds, likelihood and probability) and of rate (incidence and prevalence) by the end of June for a paper to be given at the August meeting of the ASA. The time involved is estimated based on the time required for three similar papers.

1h. Extend the existing web-based Ratio Statement Validator Program (RSVP) to analyze phrases, to handle synonyms, to handle words that may be repeated in both part and whole and to handle some pronouns. These and other limitations are described in the paper by Burnham and Schield (2005). This is a major effort and success in the time allotted is not predictable so the extent of this extension task may need to be renegotiated. Tom Burnham is responsible for design, programming and testing this major extension.
Timing: This program is to be completed by December 2007 for testing in spring 2008. Based on

feedback from students and faculty, this program will be updated by the end of April for testing by Augsburg students in May and June.

1h. Extend the enhanced web-based Ratio Statement Validator Program (RSVP) to handle comparisons of numbers. Tom is responsible for design, programming and testing this extension.
Timing: Completion by January 2008 for testing by Augsburg students in spring day school.

1h. Extend the enhanced web-based Ratio Statement Validator Program (RSVP) to handle the grammar of chance (risk, odds, likelihood and probability) and the rate grammars involving prevalence and incidence. Tom is responsible for design, programming and testing this extension.
Timing: Completion by the end of April 2008 for testing by Augsburg students in summer school.

1i. Analyze the use of double ratios (e.g., relative risk and odds ratio) as evidence for causal connections. This analysis must be completed by the end of June, 2008 for a paper to be given at the national meeting of the ASA in August. Preliminary work has already started on this task. The time estimate is based on the time involved in doing similar papers.

Dr. Larry Lesser, Associate Professor at the University of Texas in El Paso, TX has this task:

- Review the feedback from the project participants and evaluate the adequacy, the completeness of this package to be called a turnkey system and the readiness of this package to be deployed nationally. His primary responsibility is to make an independent assessment of both the strengths and weaknesses of the system in meeting the need of faculty for a complete package of education, textbook and support in order to teach statistical literacy.
Timing: The project reviewer will receive the participants' written feedback by 15 May 2008 and will submit his final report to the PI by 15 June.

Dr. Velma Lashbrook, Adjunct Professor at Augsburg College, has these tasks:

- Design assessments of educational materials and faculty development. Prepare instruments and procedures by May 2007. Implement in conjunction with the faculty-development courses in the summer and fall of 2007 and the spring of 2008.   Analyze and report assessment results by June 15, 2008.

DISSEMINATION

Dissemination is an important aspect of this project. At least three papers are expected based on this 18 month project. These papers will be presented at the national meeting of the American Statistical Association and published in the Proceedings of the ASA Section on Statistical education.

The PI is internationally respected and will be giving talks on statistical literacy in Brazil (ICOTS) this summer and in Lisbon (ISI) next summer. Future talks will certainly reference the results of this project and thereby disseminate the results not only on a national scale – but on an international scale.

All documents created under this grant will be hosted at www.StatLit.org. All of those documents will be encoded with HTML Dublin Core metadata.

PROJECT TIMELINE

The project timeline shown on the last page of this section is very complex because of the many dependencies. Considerable effort has been expended in planning the timing of the various elements of this project so as to deliver a faculty development system that is tested by three different groups of faculty.

EVALUATION

As mentioned in the introduction, the Statistical literacy is an interdisciplinary curriculum in the liberal arts. It is a unique combination of mathematics, statistics, epidemiology and critical thinking. Students need and like this course. It is a graph-based, word-centered course that stands along side the traditional algebra and calculus-based courses. We have argued that it is very different.

In reviewing the W. M. Keck Statistical Literacy curriculum, Peter Holmes agreed saying,
> *"The Augsburg course [in Statistical Literacy] is different. It has a different emphasis from many other courses to establish statistical literacy. It comes from a different background, but it has a lot of overlaps. And in many ways it reflects better the amount of the data that comes as part of every day life, certainly from large observational studies." What the Augsburg course "puts together is unique. That's not to say that the individual things are necessarily unique. But the package as a whole comes off as a very different package. It draws on ideas from areas which have not been in the traditional mainstream of statisticians. But they are there and they are statistical and we should be drawing on them." The Augsburg "approach to statistical literacy goes beyond numeracy by focusing on reading and communicating those topics studied in numeracy." The emphasis of this course "is much more in line with the sort of statistical literacy needed by most people in everyday life to read the news, by those who are in business commerce or management and by policy makers."* See Schield (2004b).

The goal of this project is *"to provide faculty with a turn-key system for teaching statistical literacy."* This complete "ready to use" system includes educational materials and faculty development. Most of this will be web-based to allow reasonable cost national dissemination during and after this project.

*We have argued that this Statistical Literacy Turnkey System project has **intellectual merit** and that implementing this project will have **broad impact**.* We will review how this project fits in with the NSF criteria and priorities:

- Collective action: By involving some 24 faculty from two and four-year colleges, this project fits in with the need for collective action as emphasized in a report from the National Academies (2003, "Improving Undergraduate Instruction in Science, Technology, Engineering and Mathematics," (http://www.nap.edu/books/0309089298/html), which identifies the importance of expanding faculty and scholarly networks to promote effective instruction and to support rapid dissemination and adaptation of successful educational innovations.

- Contribution of Knowledge: By developing statistical literacy as an interdisciplinary curriculum in the liberal arts, statistical literacy fits in with the CCLI program's state need "both for the development of exemplary courses and teaching practices and for assessment and research efforts in undergraduate STEM education that build on and contribute to the pool of knowledge concerning effective approaches in STEM undergraduate education."

In terms of the CCLI cyclic model, this project involves "Creating new learning materials and teaching strategies," "Developing Faculty Expertise" and "Implementing Educational Innovations."

- By focusing on the quantitative needs of students who don't take a quantitative course, this project satisfies the CCLI learning materials & teaching strategies criteria which states that "All projects should lead to exemplary models that address the varied needs of the Nation's diverse undergraduate student population. They may include activities that help faculty develop expertise in adapting these innovations and incorporating them effectively into their courses, the next step in the cycle."

- By focusing strongly on faculty development, this project satisfies the CCLI cyclic model's "developing faculty-expertise" condition that "successful projects should provide professional development for a diverse group of faculty so that new materials and teaching strategies can be widely implemented."

- By focusing on the generation of papers and the giving of talks at national conferences in different disciplines, this project satisfies the CCLI cyclic model's implementing educational innovation criteria: "To ensure their broad based adoption, successful educational innovations (such as learning materials, teaching strategies, faculty development materials, assessment and evaluation tools) and the research relating to them should be widely disseminated."

This project also addresses other features considered important by NSF:

- Quality, Relevance and Impact: This project clearly addresses a recognized need for quantitative training by students in non-quantitative majors. As data increases, the ability to read and interpret data becomes increasingly relevant. Statistical Literacy is relevant to life in a modern society and it will have a major impact if it can help students make better judgments as informed citizens.

- Student focus: This project has a clear relation to student learning. It addresses the needs of students in non-quantitative majors and it utilizes the web-based tools that are expected by today's students.

- Use of and Contribution to Knowledge about STEM education. This project reflects the highest quality thinking about the applications of mathematical, statistical and epidemiological thinking to the quantitative needs of undergraduates as citizens. It builds on projects in statistics and quantitative literacy such as the Chance project. It has a recognized place for distribution at www.StatLit.org.

- STEM Education Community Building: This project provides extensive opportunity for interactions between the investigators and others in the undergraduate STEM community. The PI will be attending six national conferences during this 18 month project. At those conferences in which the PI gives a paper, there will be extensive interaction. At the national meetings of the American Statistical Association, the PI has held 8 statistical literacy sessions involving faculty from outside mathematics and statistics. A similar session is planned during this grant.

- Expected Measurable Outcomes: This project has goals and objectives that are translated into measurable outcomes that can be used to track progress, guide the project and evaluate its ultimate success. Such outcomes include student satisfaction with the new web-based drills and faculty satisfaction with the new "turn-key" system.

- Project Evaluation: This project has plans for both formative and summative assessment. Both forms of assessment were in place in the last grant from the W. M. Keck Foundation and they will be continued in this project.

In conclusion, if statistical literacy is to be disseminated nationally in a timely manner, it must be a "turn-key" system: complete, efficient and effective. This project has proposed such a system: a system that will be "ready to go" using web-based technology. Implementing this 'turn key" faculty-development system will be a major step forward in helping faculty teach statistical literacy.

| **PROJECT TIMELINE** | | | Start | 1 January, 2007 |
| **Statistical Literacy Turn-Key System** | | | End | 30 June, 2008 |

2007		
January	Schield	Attend MAA, promote participation in project
February	Burnham	Develop on-line drill program for identifying part and whole in ratios.
	Schield	Test on-line part-whole program at Augsburg in Spring Day
March	Isaacson	Deliver web-base faculty development program for teaching statistical literacy
	Schield	Test parts of on-line training program
	Copes	Complete edit of Chapter 7 and rest of book
	Burnham	Create on-line program to drill students on analyzing articles
April	Schield	Print updated version of textbook for use throughout the grant
May	Schield	Attend Journalism (IRE/CAR) in Colombia MO. Promote participation by faculty.
	Schield	Attend USCOTS in Ohio and at IASSIST in Canada. Promote participation.
	Burnham	Analyze grammar of chance, prevalence and relative risk
June	Schield	Complete field-tested evaluations for essays and index
	Schield	Develop teacher training materials and project brochure
	Schield	Submit ASA paper on grammar of chance, prevalence & Relative risk
	Isaacson	Conduct summer test of web-based faculty development course (8 weeks)
July	Schield	Attend ASA (Salt Lake City): 7/29 - 8/02, 2007
	Schield	Give paper on grammar of chance/incidence at ASA national conference
August	Isaacson	Update web-based faculty development course
September	Schield	Start fall 2007 on-line teacher training. 8 week course
November	Schield	Attend AMATYC (New Orleans): 11/15 - 18, 2007
December	Burnham	Extend existing program to handle phrases, repeated nouns and pronouns.
	Isaacson	Update mini web-based faculty development courses
2008		
January	Schield	Attend MAA (San Diego): Jan 6-9, 2008
	Schield	Start Spring 2008 mini on-line development sessions. 10 weeks total.
March	Burnham	Extend existing program to handle more grammars (chance & incidence)
April	Faculty	Submit evaluations of text and teacher training materials and support
	Schield	Compile responses and submit to project reviewers
	Burnham	Extend existing program to handle comparisons of numbers
May	Schield	Attend IRE/CAR in Colombia MO. Promote participation by journalism faculty.
	Burnham	Analyze use of double ratios as evidence for causation.
June	Isaacson	Analyze use of web-based faculty development in statistical literacy
	Reviewer	Submit project review
	Evaluator	Complete project evaluation
	Schield	Submit final project report

Best, Joel (2001). *Damned Lies and Statistics.* University of California Press.

Best, Joel (2004). *More Damned Lies and Statistics.* University of California Press.

Burnham, Tom and Milo Schield (2005). An Online Grammar-parsing Program That Decodes Ordinary English Descriptions and Comparisons of Percentages and Rates. *2005 American Statistical Association Proceedings of Section on Statistical Education*, [CD-ROM] 2202-2208. At www.StatLit.org/pdf/2005BurnhamSchieldSA.pdf.

Isaacson, Marc (2005). Statistical Literacy – Online at Capella University. 2005 *American Statistical Association Proceedings of the Section on Statistical Education*, [CD-ROM] 2244-2252. At www.StatLit.org/pdf/2005IsaacsonASA.pdf.

Olsen, Chris (2005). Epidemiology as a Context for Teaching Confounding in Elementary Statistics. *2005 American Statistical Association Proceedings of the Section on Statistical Education* [CD-ROM] 2289-2292. At www.StatLit.org/pdf/2005OlsenASA.pdf

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Schield, Milo and Thomas Burnham (2003). Confounder-induced Spuriosity and Reversal: Algebraic Conditions for Binary Data Using a Non-Interactive Model. *2003 American Statistical Association Proceedings of Section on Statistical Education*. [CD-ROM], 3690 - 3697. At www.StatLit.org/pdf/2003SchieldBurnhamASA.pdf.

Schield, Milo and Thomas Burnham (2004). Confounder Resistance and Confounder Intervals for a Binary Confounder. *2004 American Statistical Association Proceedings of the Section on Statistical Education.* [CD-ROM], 2781 - 2788. At www.StatLit.org/pdf/2004SchieldBurnhamASA.pdf.

Schield, Milo and Thomas Burnham (2006). *Binary Confounders as Mathematical Objects: Confounder Influence and Confounder Intervals.* MAA At www.StatLit.org/pdf/2006SchieldBurnhamMAA.pdf.

Schield, Milo (2000). *Statistical Literacy and Mathematical Reasoning*. International Conference on Mathematics Education (ICME-9), Tokyo. At www.StatLit.org/pdf/2000SchieldICME.pdf.

Schield, Milo (2004a). Statistical Literacy and Liberal Education at Augsburg College. *Peer Review,* Sept. 2004, 7-14. AACU. At www.StatLit.org/pdf/2004SchieldAACU.pdf.

Schield, Milo (2004b). Information Literacy, Statistical Literacy and Data Literacy. *IQ (IASSIST Quarterly)*, 7-14. At www.StatLit.org/pdf/2004SchieldIASSIST.pdf.

Schield, Milo (2004c). *Statistical Literacy Curriculum Design.* IASE Curriculum Design Roundtable. At www.StatLit.org/pdf/2004SchieldIASE.pdf.

Schield, Milo (2004d). *Three Graphs to Promote Statistical Literacy.* International Conference on Mathematics Education (ICME-10). At www.StatLit.org/pdf/2004SchieldICME.pdf.

Schield, Milo (2005a). *Statistical Prevarication: Telling Half Truths Using Statistics.* 2005 International Assoc. of Statistical Educators (IASE). Invited paper, Sydney. At www.StatLit.org/pdf/2005SchieldIASE.pdf.

Schield, Milo (2005b). Statistical Literacy and Chance. *2005 American Statistical Association Proceedings of the Section on Statistical Education.* [CD-ROM] 2302-2310. At www.StatLit.org/pdf/2005SchieldASA.pdf.

Schield, Milo (2006a). *Statistical Literacy Survey Analysis: Reading Tables and Graphs of Rates and Percentages.* International Conference on Teaching Statistics (ICOTS-7). At www.StatLit.org/pdf/2006SchieldICOTS.pdf.

Schield, Milo (2006b). *Presenting Confounding and Standardization Graphically.* Draft for STATS Magazine. At www.StatLit.org/pdf/2006SchieldSTATS.pdf.

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Terwilliger, Jim and Milo Schield (2004). *Frequency of Simpson's Paradox in NAEP Data.* American Educational Research Association. At www.StatLit.org/pdf/2004TerwilligerSchieldAERA.pdf.

DR. MILO A. SCHIELD, Principal Investigator (PI).

Professional Preparation:

Iowa State University	Physics	B.S. 1962
University of Illinois	Physics	M.S. 1964
Rice University	Space Physics	Ph.D., 1968

Appointments:

Augsburg College	Department of Business Administration	1985
St. Paul Companies	Senior Operations Researcher	1978
Fox and Co., CPA	Senior Consultant	1975
Bantam Data, Inc.	President	1972
Schield Stock Service, Inc.	President	1970
University of Iowa	Instructor, Physics Department	1968

Publications (limited to 10):

All significant publications are closely related to this project. A broad overview of statistical literacy is provided in Schield (2004a). Statistical literacy is related to mathematics in Schield (2000) and to information literacy in Schield (2004b). Details of the statistical literacy curriculum design are provided in Schield (2004c, 2004d and 2006b). Statistical literacy is related to chance in Schield (2005b). Critical thinking aspects of statistical literacy are presented in Schield (2005a). A statistical literacy analysis of the influence of confounders on NAEP scores is presented in Terwilliger and Schield (2004). For theoretical papers on the mathematics of confounding, see Burnham's biographical sketch.

1. Schield, Milo (2000). *Statistical Literacy and Mathematical Reasoning*. International Conference on Mathematics Education (ICME-9), Tokyo. See www.StatLit.org/pdf/2000SchieldICME.pdf.

2. Schield, Milo (2004a). Statistical Literacy and Liberal Education at Augsburg College. *Peer Review,* Sept. 2004, 7-14. American Assoc. of Colleges and Universities. See www.StatLit.org/pdf/2004SchieldAACU.pdf.

3. Schield, Milo (2004b). Information Literacy, Statistical Literacy and Data Literacy. *IQ (IASSIST Quarterly)*, 7-14. See www.StatLit.org/pdf/2004SchieldIASSIST.pdf.

4. Schield, Milo (2004c). *Statistical Literacy Curriculum Design.* IASE Curriculum Design Roundtable. See www.StatLit.org/pdf/2004SchieldIASE.pdf.

5. Schield, Milo (2004d). *Three Graphs to Promote Statistical Literacy.* International Conference on Mathematics Education (ICME-10). See www.StatLit.org/pdf/2004SchieldICME.pdf.

6. Schield, Milo (2005a). *Statistical Prevarication: Telling Half Truths Using Statistics.* 2005 International Assoc. of Statistical Educators (IASE). Invited paper, Sydney. At www.StatLit.org/pdf/2005SchieldIASE.pdf.

7. Schield, Milo (2005b). Statistical Literacy and Chance. *2005 American Statistical Association Proceedings of the Section on Statistical Education.* [CD-ROM] 2302-2310. See www.StatLit.org/pdf/2005SchieldASA.pdf.

8. Schield, Milo (2006a). *Statistical Literacy Survey Analysis: Reading Tables and Graphs of Rates and Percentages.* International Conference on Teaching Statistics. At www.StatLit.org/pdf/2006SchieldICOTS.pdf.

9. Schield, Milo (2006b). *Presenting Confounding and Standardization Graphically.* Draft for STATS Magazine. At www.StatLit.org/pdf/2006SchieldSTATS.pdf.

10. Terwilliger, Jim and Milo Schield (2004). *Frequency of Simpson's Paradox in NAEP Data.* Presented at the American Educational Research Association. See www.StatLit.org/pdf/2004TerwilligerSchieldAERA.pdf.

Synergistic Activities:
Dr. Schield, the Director of the W. M. Keck Statistical Literacy project, is the Principal Investigator.

He is a tenured professor in Business Administration at Augsburg College with a Ph.D. in Space Physics (Rice University). He has been chair of the Business Department: the largest department at Augsburg.

He has taught traditional statistics for over 10 years; he has taught critical thinking at the undergraduate level for 6 years and at the graduate level for two.

He has given over 50 talks and papers on statistical literacy. In the US, he has given talks at Project Kaleidoscope (PKAL), Making Statistics More Effective in Schools of Business (MSMESB), the Association of Public Data Users (APDU), American Mathematical Association (MAA), the American Mathematics Association of Two Year Colleges (AMATYC), and the US Department of the Census and the Bureau of Labor Statistics. Internationally, he has given talks at the International Conference on Teaching Statistics (ICOTS), Singapore, and the International Conference on Mathematics Education (ICME) in Tokyo and in Copenhagen, along with conferences sponsored by the International Association of Statistical Educators (IASE) in Sweden and Australia. He has given invited talks at colleges and universities in China, Singapore, Japan, Australia, South Africa England, Scotland and Wales.

He is giving talks at the May meeting of the International Association of Social Science Information Services and Technology (IASSIST) in Ann Arbor, at the July International Conference on Teaching Statistics (ICOTS) in Brazil, and at the August national meeting of the American Statistical Association (ASA) in Seattle. He is also giving a 2 hour workshop at the first two conferences and is organizing a session on statistical literacy at the third.

CONFERENCES: Dr. Schield has organized sessions on statistical literacy at the last seven national meetings of the American Statistical Association. Speakers have included Dr. Donald Rubin (Harvard), Dr. Joel Best, author of *Damned Lies and Statistics*, Joe Abramson, author of *Making Sense of Data,* Nicholas Eberstadt, author of *The Tyranny of Numbers,* Jessica Utts, author of *Seeing Through Statistics*, Robyn Dawes, author of *Everyday Irrationality*, Vic Cohen, author of *News and Numbers,* Tom Wonnacott, author of numerous statistics textbooks and Jane Miller, author of *The Chicago Guide to Writing about Numbers.*

RECOGNITION: In his book, *More Damned Lies and Statistics,* author Joel Best titled the last chapter, *Toward Statistical Literacy.* After noting the many problems facing this movement, he said, "*Despite these obstacles, a small educational movement advocating statistical literacy has emerged. Professor Milo Schield, Director of the W. M. Keck Statistical Literacy Project at Augsburg College in Minneapolis, is the movement's leading voice*."

Collaborators and Co-Authors:
    Tom Burnham, Cognitive Consulting in San Antonio, TX.
    Jim Terwilliger, Minnesota Department of Education, NAEP Coordinator for the State of Minnesota.

Thesis advisor and Post-graduate Sponsor: None.

Marc Isaacson, Assistant Professor, Business Administration, Augsburg College, Minneapolis, MN.

Marc Isaacson has an undergraduate liberal arts degree and an M.S. degree in Engineering from Rensselaer Polytechnic Institute. He is an assistant professor in the Department of Business Administration at Augsburg College. He has taught introductory statistics to business majors at Augsburg College. His interests include quantitative problem solving, quality engineering and entrepreneurship.

Marc was an in-class reviewer of Augsburg's Statistical Literacy course. He has designed three on-line courses: two statistics courses and a half-semester course in Statistical Literacy. The on-line statistical literacy course was offered 11 times in the first year. In 2005, Marc presented results of his course development in the following paper at the national meeting of the American Statistical Association.

Isaacson, Marc (2005). Statistical Literacy – Online at Capella University. *2005 American Statistical Association Proceedings of the Section on Statistical Education* [CD-ROM] 2244-2252. See www.StatLit.org/pdf/2005IsaacsonASA.pdf.

Dr. Larry Copes, Educational Consultant in Minneapolis, MN.

Dr. Copes holds bachelors and masters degrees in mathematics and a Ph.D. in mathematics education.

In 1979, he founded the Perry Network, an informal community of educators and researchers interested in understanding and using William Perry's scheme of intellectual and ethical development.

Today he is Director of the Institute for Studies in Educational Mathematics and a mathematics education consultant. He helps prepare middle-and high-school teachers for teaching standards-based curricula, teaches on-line as well as classroom courses, works with a project writing electronic inquiry-based curricula for teachers, and serves as an occasional free-lance editor of mathematics books for teachers.

Dr. Copes is very familiar with statistical literacy having attended statistical literacy seminars and having completed a very successful introductory edit of the first six chapters of the Statistical Literacy textbook.

Tom Burnham, Cognitive Consulting in San Antonio, Texas.

Tom is a private consultant in San Antonio, TX. He has worked as an analyst and designer of computer operating systems and large applications with companies such as Eagle Signal and Datapoint. He has maintained a life-long focus on issues involving epistemology, concept formation and conceptual integration. He has co-authored the following papers with the Principal Investigator.

Burnham, Tom and Milo Schield (2005). An Online Grammar-parsing Program That Decodes Ordinary English Descriptions and Comparisons of Percentages and Rates. *2005 American Statistical Association Proceedings of the Section on Statistical Education*, [CD-ROM], 2202-2208. See www.StatLit.org/pdf/2005BurnhamSchieldSA.pdf.

Schield, Milo and Thomas Burnham (2002). Algebraic Relations between Relative Risk, Phi and Measures of Necessity and Sufficiency in 2x2 Tables. *2002 American Statistical Association Proceedings of Section on Statistical Education*. [CD-ROM], 3089 - 3094. See www.StatLit.org/pdf/2002SchieldBurnhamASA.pdf.

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Schield, Milo and Thomas Burnham (2006). *Binary Confounders as Mathematical Objects: Confounder Influence and Confounder Intervals.* MAA conference presentation. See www.StatLit.org/pdf/2006SchieldBurnhamMAA.pdf.

Dr. Larry Lesser, Associate Professor, Univ. of Texas, El Paso, TX.

Lawrence (Larry) Lesser has a BA in mathematics and mathematical sciences, an MS (and all required coursework for a PhD) in Statistics, and a PhD in Mathematics Education.

He is an Associate Professor in the Department of Mathematical Sciences at the University of Texas at El Paso, and also has previous experience as a high school mathematics department chair and a state agency statistician. He is on the Research Advisory Board of the Consortium for the Advancement of Undergraduate Statistics Education (CAUSE), and he served a three-year term on the Editorial Board for the Journal of Statistics Education(JSE). Some of Lesser's scholarship, such as his chapter on Simpson's Paradox in the 2001 NCTM Yearbook, has important direct connections to statistical literacy, and he also has first-hand experience teaching introductory statistics courses with a statistical literacy approach.

Dr. Velma Lashbrook, Adjunct Professor at Augsburg College

Velma J. Lashbrook has an Ed.D. in Communication and Educational Psychology from West Virginia University. In addition to the study of communication and learning theories, she received extensive education in measurement development, research design, and statistics.

She currently teaches in the Master of Arts in Leadership program at Augsburg College; one of the classes she teaches is Research Methods. At Augsburg, she is an assessment consultant for the Center for Teaching and Learning; in this capacity, she currently consults with 17 teams on the development of learning outcomes, instructional practices, and assessment strategies for implementing a new general education curriculum.

In addition, she is an online facilitator for the University of Phoenix Online. She teaches courses in professional development, critical thinking, and research methods.

She also works as a consultant/evaluator/workshop facilitator for The Collaboration for the Advancement of College Teaching and Learning. In this role, she works with higher education faculties to improve student learning by designing deep, collaborative learning experiences and by developing effective assessment and feedback systems to measure student learning.

Prior to her return to higher education in 1999, she was Director of Research and Vice President of Research and Development for Wilson Learning Corporation, a training and development firm serving multinational companies. In that role, she led a team of researchers and designers to develop learning and measurement systems to address sales, customer service, leadership, and team issues. She developed the firm's capabilities in the areas of needs assessment, measurement development, and program evaluation.

She has authored or co-authored the following papers for recent conferences of The Collaboration for the Advancement of College Teaching and Learning:

- *Building a Learning-Centered Institution,* February 2006, Bloomington, MN – invited preconference workshop
- *The World Café: Conversations About Multicultural Learning,* November 19, 2005, Bloomington, MN – competitively selected session conducted with Nancy Rodenberg
- *Walking The Talk,* February 17-18, 2005, Bloomington, MN – invited facilitator.
- *Collaborative Design: Assessing Augsburg's Core Curriculum,* February 18, 2005, Bloomington, MN – competitively selected session conducted with Marilyn Florian, Mark Engebretson, and Michael Schock
- *Crafting Questions That Challenge People to Think,* November 18, 2004, Bloomington, MN
- *Developing Compassionate, Inquisitive Leaders Prepared for Global Responsibility,* February 20, 2004, Bloomington, MN – competitively selected session conducted with Linda Barnhart

Her most recent article is:
- Lashbrook, V.J. (2006, Winter). Authentic teaching: Doing what we know is right. *On Teaching & Learning, 20* (2), 2, 5, 10-11, 13.

A.   SENIOR PERSONNEL (2008 salaries for Schield and Isaacson are budgeted at 3.5% more than those in 2007.)

Dr. Schield, the Principal Investigator, will earn $21,000 on his 2007 nine-month rate of $48.97 per hour. He will work for 1.2763 months in the first year ($11,000) and 1.1211 months ($10,000) in the second. During the first year, he will produce an index of essays along with field-tested evaluations and will develop teacher training materials and brochure content (20 hours, $1,000). He will build a web-based power point slide presentation with audio attachments giving an overview of the various web-based faculty development sessions. (40 hours, $2,000). As an overload, he will moderate a web-based faculty development session (Augsburg's standard rate for full professors; $3,500). Doing this as an overload allows him to teach the statistical literacy courses needed to monitor the student impact of this project and to teach the business statistics courses needed by his department. While this amount is about 0.5 months based on his nine-month salary, the time spent on this task is spread over 8 weeks. Schield will also manage the project and assess project outcomes (90 hours; $4,500). During the second year, he will generate more evaluations (20 hours, $1,000), moderate a series of three mini faculty development sessions (Augsburg's standard rate, $3,500) as an overload and also manage the project, assess outcomes and submit the final report (110 hours, $5,500).

Marc Isaacson, Senior Researcher, will earn $7,000 based on his 2007 nine-month rate of $34.03 per hour. . He will work for 1.0687 months the first year ($6,400) and 0.0968 months the second ($600). During the first year, he will use Moodle to create a full web-based faculty development system that can be offered as three separate courses (90 hours, $3,000) and he will moderate a web-based faculty development session (Augsburg's standard rate of assistant professors; $3,400) during the summer. During the second year he will update the web-based faculty development system based on feedback from the participants and he will prepare a draft of an ASA paper summarizing the web-based aspects of the project (18 hours, $600).

Velma Lashbrook, Project Evaluator, will earn $6,000 based on a 2007 nine-month rate of $6,000 per month. She will work for 0.5 months the first year ($3,000) and 0.5 months the second ($3,000). In the first year, the project evaluator will review the proposed assessment plan and survey instruments prepared by the Principal Investigator, make suggestions and approve the resulting plan and instruments as being adequate for a summative assessment (88 hours, $3,000). The Principal Investigator will conduct formative assessments during the project. In the second year, the project evaluator will be given the results of all surveys and will make an independent summative assessment on the entire project (88 hours, $3,000).

C.   FRINGE BENEFITS: Fringe Benefits are calculated at 7.65% for Medicare and FICA taxes.

E.   TRAVEL: All travel is for the Principal Investigator to attend conferences, give papers and encourage faculty to consider participating in this grant. Travel includes airfare, lodging and conference registration but no food. First-year domestic travel ($5,800) is to New Orleans (MAA, $1,200, January), Colombia MO (IRE, $700, May), to Colombia, OH (USCOTS, $1,200, May), to Salt Lake City UT (ASA, $1,500, August) and to New Orleans LA (AMATYC, November, $1,200). Second-year domestic travel ($2,000) is to San Diego CA (MAA, Jan, $1,200). The detailed travel budget is shown on page 3.

F.   PARTICIPANT SUPPORT COSTS: Faculty participant costs are budgeted at $36,000 the first year and $8,000 the second. First-year participants are budgeted to spend 70 hours on the full faculty development module including exercises, quizzes and tests plus 10 hours on their written evaluations. These 80 hours at $25/hour gives $2,000 per participant.   In the first year, six faculty are budgeted for the summer ($12,000) and 12 for the fall ($24,000). Second-year participants will be taking mini-sessions. The $8,000 budgeted would cover 8 people at $1,000 per person. But since there are three distinct mini-sessions, this may cover from 16 to 24 people at a reduced amount.

G.   OTHER DIRECT COSTS:
G1. Materials are budgeted at nominal amounts: $1,455 the first year and $303 the second.   The first year expenses are for copies of brochures promoting participation in this project and for gratis copies of the statistical literacy textbook (20 copies at $50@). .   The second year expenses are for additional copies of the brochure and (funds available) more gratis copies of the book.

G3. CONSULTING:

G3a. Consultant Larry Copes will earn $7,000 in the first year: $2,000 for editing chapter 7 and $5,000 for editing the entire 7 chapter book as a unit. These terms are consistent with his regular rate as a textbook editor.

G3b. Consultant Tom Burnham receives $24,000 in the first year and $12,000 in the second. Predicting the time required to build a computer program is speculative at best so changes may be expected. Tom's normal rate is $40 per hour. For this grant, Tom has agreed to work at an hourly rate of $20/hour. Tasks in the first year include Developing on-line drill program for identifying part and whole in ratios (200 hours, $4,000), Developing an on-line drill program to drill students on evaluating articles (100 hours, $2,000), Analyzing the grammar of chance, prevalence and relative risk (100 hours, $2,000) and Extending the RSVP program to handle phrases, synonyms, repeated nouns and pronouns (800 hours, $16,000).
Tasks in the second year ($12,000) include Extending RSVP to handle comparisons of numbers (100 hours, $2,000), Extending RSVP to handle incidence and chance (300 hours, $6,000) and Analyzing the strengths and weaknesses of double ratios when used as evidence of causation (200 hours, $4,000).

G3c. Consultant Larry Lesser, the project reviewer, receives $3,000 in the second year. Based on a rate of $50 per hour, he is expected to spend 1.5 weeks or 60 hours on this review. He will have participated in the statistics mini-course (3 weeks, 40 hours) so he will have a personal understanding of what the web-based faculty development involves. He will then have 20 hours for analyzing the reports of other participants and forming his conclusions.

H. INDIRECT COSTS:
Augsburg has a negotiated indirect cost agreement of 40% of salaries and benefits.

SCHIELD'S DETAILED TRAVEL BUDGET   TOTAL   2007   2008
                                          $7,000 $5,800 $1,200

Total	Registration	Transportation	Lodging	Days	Hotel

5-Jan-07   Mathematics Association of America (MAA) in New Orleans LA 5-9 Jan 2007
                 Schield promotes participation in this project

$1,200	$300	$300	$600	4	$150

12-May-07   Investigative Reporters & Editors (IRE) Computer Aided Reporting (CAR) boot camp, Colombia MO
                 Schield solicits participation in grant by journalism faculty.

$700	$100	$300	$300	3	$100

17-May-07   US Conference on Teaching Statistics (USCOTS). Colombia OH May 17-19, 2007

$1,200	$300	$300	$600	4	$150

29-Jul-07   Joint Statistical Meeting of the American Statistical Association, Salt Lake City UT.
                 Present paper, organize session on statistical literacy. Solicit participation.

$1,500	$300	$300	$900	6	$150

14-Nov-07   American Mathematical Association at Two Year Colleges (AMATYC) national meeting
                 National meeting at New Orleans: 15-18 Nov., 2007
                 Schield solicits participation in this grant.

$1,200	$300	$300	$600	4	$150

5-Jan-08   Mathematics Association of America (MAA) in San Diego 6-9 Jan 2008
                 Schield solicits participation in this grant.

$1,200	$300	$300	$600	4	$150

12-May-08   Investigative Reporters & Editors (IRE) Computer Aided Reporting (CAR) boot camp, Colombia MO
                 Schield solicits participation in grant by journalism faculty.

$0	$0	$0	$0	0	$100

                 May attend this one if the 2006 IRE/CAR doesn't work out.

Suggested Reviewers:

Provide the First, Middle, and Last Name of suggested reviewers that you believe are especially well qualified to review this proposal

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Richard L. Scheaffer, Past President of the ASA.

Joel Best, Author of "Damned Lies and Statistics", Univ. of Delaware

Lynn Arthur Steen, Author of "Achieving Quantitative Literacy." St. Olaf College.

Neil Lutsky, Carleton College, Northfield, MN

David Bressoud, Macalester College, St. Paul, MN.

Paul J. Fields, Editor of STATS magazine, Statistics Department at Brigham Young University

Bernard L. Madison, President of the National Numeracy Network, Dept. of Mathematics, University of Arkansas.

Chris Olson, Cedar Rapids High School.

Allan J. Rossman, Statistics Department, California Polytechnic State Univ.- San Luis Obispo.

Reviewers Not to Include:

Designate persons you would prefer not review this proposal and indicate why.

Joan B. Garfield (Univ. Mn)

Deborah J. Rumsey (Ohio State)

Carol Joyce Blumberg (Winona State).

While these are three very highly-respected leaders in statistical education, they may support a competing view of statistical literacy that sees it as being just a part of traditional statistics.