

## TEACHING STRATEGIES TO PROMOTE STATISTICAL LITERACY: REVIEW AND IMPLEMENTATION

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*In the past few years statistics educators have emphasised the importance of statistical literacy in the statistics education reform movement. Many educational researchers argue that the topic of statistical literacy should be part of an introductory statistics course syllabus. This article gives an overview of useful techniques for developing a reform-based statistics course, underlining the place of statistical literacy in this framework. Summarised recommendations incorporate many innovations employed in a variety of successful statistics classes today. We suggest that introductory statistics courses, and in particular the statistical literacy component, will benefit from additional curricular material aimed at encouraging students to become informed and critically thinking consumers of statistical information, thereby promoting motivation to learn statistics. The directions and approaches to developing such curriculum material are discussed.*

### INTRODUCTION

During the last twenty years there has been growing attention to the teaching and learning aspects of statistics education (see, e.g., Moore, 1997; Garfield, 1993; Garfield, 1995; Garfield & Ben-Zvi, 2002; Garfield & Ben-Zvi, 2007). It is widely recognised that statistics is one of the most important quantitative subjects in a university curriculum (Watson, 1997), but it is also acknowledged that teaching statistical courses is challenging because they serve students with varying backgrounds and abilities, many of whom have had negative experiences with statistics and mathematics. Statistics education research over the last decade has emphasised the need of reform in the teaching of statistics with a growing body of research in the area. The purpose of this paper is to review the literature related to statistics pedagogy and the current thinking of leading educators in the field. We attempt to summarise the recommendations and techniques which can be potentially useful in teaching and learning statistics with special focus on strategies to promote statistical literacy and motivate students to learn statistics. We have to note that because of space limitations the following only represents a sample of the work and progress in statistics education.

### CURRENT STATE OF TEACHING OF STATISTICS

#### *Identified Problems in Teaching and Learning Statistics*

Despite the widespread emphasis on reform in the teaching of statistics, even today statistics education can still be viewed as a new and emerging discipline, when compared to other areas of study and inquiry (Garfield & Ben-Zvi, 2007). There is a vast amount of research focused on teaching and learning statistics and probability and on reform-oriented statistics pedagogy. Leading statistics educators formulated difficulties in learning statistics, raising issues of concern in statistical education, and urged a reform of statistics instruction and curriculum based on strong synergies among content, pedagogy, and technology (see, e.g., Garfield & Ahlgren, 1988; Garfield, 1995; Moore, 1997). All these studies share several claims about statistics pedagogy. In the Table 1 we attempt to summarise the current identified problems in teaching and learning statistics based on the relevant research in the area.

#### *Developing Statistical literacy*

One of the implications of the problems summarised in Table 1 was a movement to socially-based curriculum frameworks and towards applications-based approaches to teaching students to think critically about social situations in which data are used, sometimes referred to as applying *statistical literacy*. Gal (2002) proposed a statistical literacy model which comprises two broad interrelated components: (1) knowledge component which consists of five cognitive elements; and (2) dispositional component which consists of three related but distinct concepts.

One way of addressing the measurement and assessment of developing statistical literacy skills was developed by Watson (1997).

Table 1. List of Identified Problems in Teaching Statistics

Author	Identified Problems
Garfield (1995)	Focus on mathematical and mechanical aspects of knowledge. It results in students not being empowered to apply these aspects of statistical knowledge to solve problems generally arising from a specific context.
Garfield (1995), Verhoeven (2006)	'Maths-phobia', 'statistics anxiety' and lack of interest.
Garfield (1995), Garfield & Ben-Zvi (2002)	Ideas of probability and statistics are very difficult for students to learn.
Garfield & Ahlgren (1988)	Deficiencies in basic statistical knowledge.
Verhoeven (2006)	Statistics courses are given as 'service teaching' with no link to subject area.
Gal (2002), Schield (2004), Verhoeven (2006)	Lack of statistical literacy and inability of students in using statistics in every day life.
Watson (1997), Gal (2002)	Deficiency in tools to assess statistical thinking and statistical literacy of population in the social settings.
Smith et al. (2007)	Shortage of statistical staff (in UK universities, in particular), statistics is declining as a taught subject.
Roberts' Review (2002)	Shortage of statisticians in the workplace.

She suggested that the skills required to interpret stochastic information presented in society can be represented in a three-tiered hierarchy with increasing sophistication: a basic understanding of probabilistic and statistical terminology; an understanding of statistical language and concepts when they are embedded in the context of wider social discussion; and a questioning attitude to contradict claims made without proper statistical foundation. This research and many other educational researchers argue that the topic of statistical literacy should be a staple item on the syllabus of an introductory statistics course.

## STRATEGIES FOR REFORM-BASED TEACHING STATISTICS

### *Review of Recommendations and Suggested Strategies*

Studies that have focused on revising traditional methods of teaching statistics, suggest changes which should be implemented to enable students to receive training which is both up-to-date and relevant to society's needs. The major directions of the statistics education reform movement involve (a) change in the content of statistics courses, especially introductory level courses; (b) improving the instructional techniques used in statistical courses; (c) reforms in terms of pedagogical changes; and (d) integration of technology and using computer simulation methods in teaching statistics (see, e.g., Moore, 1997; Garfield, 1995; Mills, 2002). Several research studies formulated principles of learning statistics offering a general framework that can be applied to a variety of courses. Over a decade ago, Garfield (1995) proposed ten general principles for learning statistics formulated in the context of 'constructivism' theory. These principles have been recently regrouped into eight research-supported statements about student learning of statistics in Garfield and Ben-Zvi (2007). In Lovett & Greenhouse (2000) authors present five principles of learning, derived from cognitive theory and applied to education. They suggest that putting cognitive theory into practice will be advantageous for statistics education. Many researchers agree that using the problem solving approach in the teaching of statistics is of great benefit to both teachers and learners (see, e.g., Marriott et al., 2009).

Table 2 provides a list of some reform-based techniques, brief descriptions and examples of how they are used. We do not suggest that this list is comprehensive but it demonstrates the variety of innovative instructional techniques that are being employed in a variety of successful statistics classes today.

Table 2. Overview of Reform-Based Learning Strategies and Techniques

<b>Suggested Strategy</b>	<b>Examples of Use</b>
Integrating schemes for assessment of statistical thinking and statistical literacy in to the curriculum. (Gal, 2002; Schield, 2004; Watson, 1997)	<ul style="list-style-type: none"> <li>Using media reports and newspapers articles to assess students' ability of interpretive statistical thinking.</li> </ul>
Shifting the focus of statistics curricula from mathematical calculations to tasks of a practical nature. (Chance, 1997; Allen et al., 2009)	<ul style="list-style-type: none"> <li>Students are given problems within different contexts so they exercise what they have learned in a variety of ways.</li> <li>Consider real world examples and applications.</li> </ul>
Developing problem solving skills. (Garfield, 1993; Garfield, 1995; Marriott, 2009)	<ul style="list-style-type: none"> <li>Implement problem-based learning strategies giving students open-ended problems and taking the role of "facilitator" in the learning process.</li> <li>Use of real life examples in project work.</li> </ul>
Developing strategies to motivate students. (Garfield, 1993; Watson, 1997)	<ul style="list-style-type: none"> <li>Provide examples that have recently appeared in the media, government reports, news.</li> </ul>
Developing statistical literacy and critical thinking skills. (Wallman, 1993; Gal, 2002; Schield, 2004)	<ul style="list-style-type: none"> <li>Include statistical literacy component in the introductory statistics course.</li> <li>Focus on everyday arguments that use statistics as evidence.</li> <li>Use examples of incorrect analyses.</li> </ul>
<b>Suggested Technique</b>	<b>Examples of Use</b>
Collaborative learning. (Garfield, 1993; Garfield, 1995)	<ul style="list-style-type: none"> <li>Students work together to solve problems or discuss concepts, sharing ideas and understanding.</li> <li>Collaborative group work with computers.</li> </ul>
Active learning and introducing activities where students are able to construct knowledge. (Garfield, 1993)	<ul style="list-style-type: none"> <li>Students are engaged in data collection, reflection on and exploration of statistical concepts, and solving problems on their own.</li> <li>Small-group cooperative learning (as one of the ways for teachers to incorporate active learning).</li> </ul>
Target misconceptions through discussion and assessment. (Chance, 1997; Garfield, 1995)	<ul style="list-style-type: none"> <li>Instruction is designed so that students will be encouraged to discuss their misconceptions.</li> <li>Introduce interactive assignments with feedback.</li> </ul>
Developing the skill of communicating statistics. (Schield, 2004)	<ul style="list-style-type: none"> <li>Translate and present complex concepts into a format understandable to a wide audience.</li> <li>Ask students to explain terminology and to interpret the statistical results in everyday words.</li> </ul>
Use of technology and on-line resources. (Garfield, 1995; Mills, 2002)	<ul style="list-style-type: none"> <li>Presentation of new material with the use of statistical software.</li> <li>Simulation programs which allow students to explore statistical concepts in discovery-world environments.</li> <li>Using useful resources available online.</li> </ul>

### *Promoting Statistical Literacy: Implementation*

A sound curriculum should take into account student motivation toward the subject. We implemented some of the reform-based principles in a specially designed unit of work aimed at encouraging students to learn statistics and become critically thinking consumers of statistical information. This new material is currently under development and has the following features.

1. The developed material can be used as a 'taster' within introductory statistics course and may be used with high school students, pre-university students or adults to encourage statistical thinking.
2. The material is centred not only on the teaching of statistics but aims to give students a lasting appreciation of the value of statistics in their everyday, civic and professional lives.
3. We use only very simple statistical methods and terminology that can be grasped by students with a very limited statistics background.
4. To develop critical thinking we use examples of incorrect analyses, as a warning to those who do not think critically.

The key point of this specially designed unit of work is motivation. It is considered in the light of using media reports, examples of misleading statistics and other interesting material about real-world situations. The goal and challenge of the developed material is to help students to see the usefulness of statistical knowledge in understanding the world around them and, hopefully, make them more motivated to engage with the topic.

## CONCLUSION

In this paper we have reviewed the statistics educational literature and summarised the instructional techniques and strategies that have been proposed for teaching reform-based statistics. Currently, we are developing material for a new course which is aimed at encouraging students to learn statistics based on our findings.

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