Mapping the Field of Statistics Education Research in Search of Scholarship

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Abstract

This paper is intended as a contribution to the advancement of scholarship in the field of statistics education, which directly links with the scholarship of teaching and learning. From the literature it is apparent that statistics education research, as an interdisciplinary field, has not relied on a single tradition of research methodology. There are different research backgrounds, different research methods and methodologies are used, studies have different foci and different outcome variables have been studied. What constitutes research in statistics education is therefore still a fundamental issue, with a consequent call for more research in this field. The present study attempts to identify the major themes of statistics education research in order to provide an overview of its thematic nature. Twenty-four doctoral dissertations as well as 138 articles in three specialist statistics education journals, published between 2005 and 2009, were analyzed regarding their key themes and topics, and the frequencies of occurrences of the key themes are summarized.

We found that the teaching and learning of statistics was the most popular theme or topic. In particular, there is a growing network of researchers interested in studying the development of students' statistical reasoning. Only 15% of the literature was dedicated to technology or computer use, but the relevant studies reflect the popularity of JAVA Applets and simulation tools. Only a small portion of the literature was devoted to course design and non-cognitive factors. Our study provides both a framework for understanding developments in statistics education research and structure to the field, making it easier for future researchers to become acquainted with the discipline. In this way a contribution is made in furthering scholarship in statistics education.

Keywords: scholarship; statistics education; statistics education research; statistical themes; teaching and learning

Introduction

The idea of a scholarship of teaching and learning has won much ground over the last two decades, particularly since the publication of Boyer's work in 1990. Boyer's four types of scholarship include the scholarship of teaching which he describes as a way of transmitting knowledge as well as to transform and extend it (Boyer, 1990).

Without debating further the work of Boyer, the authors intend the research presented in this article as a contribution to scholarship in the field of statistics education, which directly links with the idea of a scholarship of teaching and learning. The point of departure is the definition of Carolin Kreber (2005) who describes the scholarship of teaching and learning as consisting of

- a deep knowledge base of the discipline (statistics in this case)
- a deep pedagogical base (generally as well as related to statistics specifically)
- an inquiry orientation
- deep reflectivity
- peer review and publication

According to this definition the scholar in statistics education builds on a deep statistical knowledge base, continually gains pedagogical knowledge on the best ways to improve statistics education, deliberately inquires into the teaching and learning of statistics, students' understanding of statistics, and reflects on own educational practices. Furthermore, the scholar should continuously reflect on successes, deliberately undertake research on own practices, gain knowledge in this way, and ultimately share the gained knowledge and expertise with the statistics education community in publications.

The article mainly contributes to the "deep pedagogical base" as indicated in the definition by Kreber. Deep or thorough knowledge of findings from research on and study of statistics education should form part of the scholar's armor in dealing with the challenges of teaching and learning. Such knowledge can also stimulate an inquiry orientation and deep reflectivity leading to systematic research and publication – as set out in the definition.

The role of knowledge from literature in the building of a knowledge base is emphasized for the developmental road towards the scholarship of teaching and learning distinguished by Weston and McAlpine (2001). In the first phase Weston and McAlpine regard reading as important for the development of an understanding of the principles underpinning teaching and learning. In the second phase an increased understanding of the complexity of teaching and learning develops, while the scholar, in a third phase, displays comprehensive knowledge of research and literature on teaching and learning (also in a specific field of study).

There is however a universal problem. Bitzer (2006) points out that "…no or little recognition is given to research into teaching, developmental efforts and publishing on teaching within and across disciplines". Trigwell & Shale (2004) argue that, although it is the responsibility of scholars to share the results of their investigations, the sad truth is that many departments and institutions do not count 'pedagogical scholarship' as part of the faculty member's scholarly production. Interestingly, the term 'scholarship of teaching and learning' is not used frequently in science publications, including mathematics, statistics, and computer science. Various authors (Bitzer, 2006; Elton, 2008) pay attention to the situation. Elton (2008), for example, refers to the "dichotomy between research and teaching" as a contributing factor to the 'unfriendly climate' and also mentions that most lecturers in the pure disciplines have only received education in the discipline (and not in teaching and learning, whether generically or in the discipline). Intending to assist the scholar-to-be in statistics education the authors attempt to organize the diverse range of studies pertaining to this field.

Given the diversity of disciplines, methodology, and orientation of the studies that can be classified under the heading of 'statistics education research', defining what constitutes research in statistics education is still a fundamental issue. In this article, therefore, statistics education as a research field in general is examined, together with an effort to suggest a categorization that may bring some clarity on the nature of the field.

Furthermore, the article seeks to map and analyze the field of statistics education research. Since the first studies on the teaching and learning of statistics appeared in the literature, there has been a proliferation of studies across many disciplines, as well as new scientific conferences and publications devoted to research in statistics education (Garfield & Ben-Zvi, 2007). Consequently, a systematic analysis of these studies is indicated in order to

summaries both the present situation and emerging trends in the field of statistics education research. A total of 138 research articles published between 2005 and 2009 in three statistics education journals (*Statistics Education Research Journal, Journal of Statistics Education* and *Teaching Statistics*), as well as 24 doctoral dissertations indexed by the International Association for Statistical Education between 2005 and 2009 were analyzed.

In the investigation a content analysis procedure was employed. The studies included in the research were analyzed according to the following questions:

1. What are the main variables of interest? What are the key themes and topics of the research articles and dissertations?
2. What are the methods and methodologies employed to research statistics education?
3. What are the organizational or disciplinary settings where statistics education is studied and in which countries?
4. What are the theories/concepts covered?

The present article pays attention only to the first of the above questions. We briefly discuss the sources used, the data collection method, and the analysis procedures. This is followed by the findings of the project with respect to the key themes and topics of the research articles. Finally, some conclusions and limitations of the study are given.

Mapping the Field of Statistics Education Studies and Research

In this section, we provide an empirically based mapping of statistics education research from 2005 to 2009. In order to map the field of interest, studies included in the research are analyzed according to their major themes or topics.

Previous Contributions

We could only locate one attempt in the literature that organize or classify statistics education research in terms of themes/topics. Becker (1996) analyzed the content of publicly accessible print literature on the teaching of statistics, examining the topic presented and whether empirical evidence is used to support the claims that are made. She presented an analysis of the content of 501 references and 29 dissertations identified by three computerized databases: the ERIC database, the PsycINFO database, and the Expanded Academic Index (ACAD). Becker suggested five major themes/topics:

1. *Computer use* (including computing in general, computer assisted instruction, software, and simulation activities).
2. *Teaching materials* (including activities, lessons, materials, texts and tools).
3. *Teaching approaches* (including teaching strategies and writing exercises).
4. *Individual differences.*
5. *Discussions* (including general discussion, course descriptions, and curriculum issues).

Becker (1996) acknowledges that she did not seek out the literature on what might be called statistical thinking or statistical reasoning. Furthermore, since the study is now almost 15 years old, recent developments have not been taken into account. For the above two reasons, the authors do not regard Becker's categorization of themes as a practical starting point, but will rather investigate categories that are more applicable to the current situation.

Sources

All relevant research articles published in three statistics education journals (*Statistics Education Research Journal, Journal of Statistics Education* and *Teaching Statistics*) between the years 2005 and 2009, and doctoral dissertations indexed by the International Association for Statistical Education, also from 2005 to 2009, were selected to serve as the corpus of this investigation. The three journals were selected because of their popularity

among academics and researchers in statistics and because these journals aim to attract researchers from various disciplines whose work relates to teaching and learning statistics (Zieffler, Garfield, Alt, Dupuis, Holleque & Chang, 2008).

The *Statistics Education Research Journal* (*SERJ*) is a peer-reviewed electronic journal of the International Association for Statistical Education (IASE) and the International Statistics Institute (ISI). *SERJ* focuses on all educational levels and seeks to advance research-based knowledge to improve the teaching, learning, and understanding of statistics or probability. Garfield et al. (2007) reported that the *SERJ*, which was established in 2002, is the first dedicated scientific journal for the statistics education discipline in which to publish high-quality research.

The *Journal of Statistics Education* (*JSE*) is an electronic journal focusing on postsecondary statistics education. However, the journal also disseminates knowledge for the improvement of statistics education at other levels, including elementary, secondary, post graduate, and workplace education. The aim of the journal is to publish articles that enhance the exchange of a diversity of interesting and useful information among educators, practitioners, and researchers around the world.

Teaching Statistics is a British journal and first appeared in 1979. The journal focuses on teachers of students aged 9 to 19 and includes articles on teaching statistics as a specialist subject. Furthermore, *Teaching Statistics* seeks to help teachers of various disciplines, such as biology, business studies, economics, geography, mathematics, sciences, and social sciences by showing how statistical ideas can illuminate their work.

The doctoral dissertations reviewed here were obtained from the website of the International Association for Statistical Education (IASE) (http://www.stat.auckland.ac.nz/~iase/publications/dissertations/dissertations.php). The IASE is a section of the International Statistical Institute (ISI) and is the main international association devoted to improve and extend statistical education at all educational levels. The webpage contains an extensive collection of dissertations since 2000 in the area of statistics education.

Data Collection and Analysis Procedures

The data were collected through a documentary analysis of 138 research articles selected from three statistics education journals and 24 doctoral dissertations in statistics education. Maree (2007) states that '[w]hen you use documents as a data gathering technique you will focus on types of written communications that may shed light on the phenomenon that you are investigating'. Document analysis therefore refers to the analysis of large numbers of documents in order to answer questions about the content and structure of a document set.

The article and dissertation analysis employed content analysis procedures in which themes and topics were chosen for examination while their frequency of occurrence within the text was recorded. Tull & Miller (2009) offers a broad definition of content analysis as follows: "Content analysis allows for the construction of a thematic understanding of data in categories and presents data in a manner that emerges from a raw or unfiltered form to something with meaning that can inform consumers of research". This kind of analysis is used to determine the presence of certain words, concepts, themes, and methods within texts to quantify their presence in an objective manner. It is also useful for examining trends and patterns in documents and its reliance on coding and categorizing of the data makes the technique particularly rich and meaningful (Stemler, 2001).

There are two general categories of content analysis: conceptual analysis and relational analysis. The present study used conceptual analysis, where a concept was chosen for examination and the frequency of its occurrences within the articles and dissertations

recorded. The articles and dissertations were coded into manageable content categories through open coding. Open coding refers to that part of the analysis that deals with the labeling and categorizing of phenomena as indicated by the data.

The themes or topics addressed by the 162 documents were identified and coded. Each document was assigned as many codes as needed to describe its themes or topics using the most detailed level of code possible. For example, a study of computer use that investigated computer assisted instruction as well as students' reasoning about a concept would receive the topic code CAI, CR (CAI = computer assisted instruction and CR = concept reasoning). Multiple topic codes were assigned to many documents. All codes were listed and similar and related codes were grouped to arrive at a smaller number of major themes or topics. Because the themes or topics may overlap to some degree, a series of sub-themes was identified to assign only one dominant code to each document.

Results

The main themes/topics identified are presented according to the distribution of main- and sub-categories, followed by a brief discussion of each main category. The most frequently covered topic in each journal and in the doctoral dissertations is identified here.

The main categories and sub-categories of topics are indicated in Table 1. The number of occurrences (frequencies) and percentages of the categories are also presented. For simplicity, all percentages reported in this study were rounded to the nearest whole number (by counting fractions of 0.5 and over as a whole number).

TABLE 1
Categories of themes/topics regarding statistics education research (N = 162)

Main Categories	Sub-categories	f	%
Teaching and learning	Teaching activities	25	15
	Teaching strategies	16	10
	Writing exercises and real data	6	4
	Total	**47**	**29**
Non-cognitive factors	Instruments to assess non-cognitive factors	5	3
	Non-cognitive factors and the learning of statistics	12	7
	Total	**17**	**10**
Statistical reasoning	Reasoning about a statistical concept	36	22
	Methods to assess statistical reasoning	4	3
	Total	**40**	**25**
Computer use	Computer assisted instruction	11	6
	Computer software packages	2	2
	Computer simulation methods	5	3
	Online instruction	6	4
	Total	**24**	**15**
Course design		20	12
Non-empirical studies		14	9

The *Teaching and learning* category includes studies about teaching activities, teaching strategies, and the use of writing exercises and real data to improve student learning. Activities are mainly performed to illustrate a statistical concept. However, activities involving computer use are not included in this category. Teaching strategies are methods implemented to help students to learn more successfully and to enable them to progress from dependent to independent learners. Experiential learning, cooperative learning, problem-based learning, constructivist instruction, and thematic instruction are strategies that are found in this category. Again, strategies involving computer use are not included here. Real data engage, and may even transform, student understanding of statistical methods or reasoning. Studies that explore and discuss the use of real data sets and writing exercises (displaying, analyzing and interpreting real data) are included in this category.

The *Non-cognitive factors* category consists of studies that investigate students' beliefs, feelings, attitudes, motivation, and anxieties related to statistics. The use of humor in class and gender differences are also included here. These studies either develop or describe instruments to assess non-cognitive factors or investigate the role of non-cognitive factors in the learning of statistics.

In the category of *Statistical reasoning*, studies that focus on students' statistical reasoning about important statistical ideas and concepts are included. Statistical reasoning comprises the way students reason with statistical ideas and make sense of statistical information. It may involve connecting one concept to another or may combine ideas about data and chance (Garfield et al., 2007). Statistical reasoning also means understanding and being able to explain statistical processes, and being able to interpret statistical results. Studies included in the first sub-category (reasoning about a concept) investigate the development of particular types of statistical reasoning using specific activities and tools. Studies that focus on assessing students' statistical reasoning are included in the second sub-category. The development of these instruments and discussions about the different types of instruments (quantitative and qualitative) are also included in this sub-category.

Four categories emerged from the *Computer use* category. First, computer assisted instruction refers to studies that discuss and develop computer-based activities that act as a component integrated with a traditional didactic course. Second, computer software packages include studies that describe or compare software designed for the purpose of performing statistical analysis. Third, computer simulation methods refer to studies that describe or develop a simulation tool to illustrate statistical ideas through simulation to construct a deeper understanding of underlying concepts. Fourth, online instruction includes studies about online courses that range from the use of web-based applications in traditional courses to full-blown online courses where there is no face-to-face contact.

The *Course design* category includes studies regarding undergraduate course design, postgraduate course design, and curriculum development (including statistics within the school mathematics curriculum). Studies investigating the effects of basic numerical and graphical skills on students' level of mastery of statistical concepts also fall under this category.

Some studies in the *Non-empirical studies* category discuss only certain concepts or themes, but are not an empirical study per se. Discussions on statistical reasoning, statistical concepts, statistical terms, misconceptions about a concept, and student experiences of a course, class preferences or teaching styles are included in this category. Textbook evaluations and literature reviews are also included here.

Journals Categorized by Topics/themes

Table 2 presents the counts of the overall topics in the literature for each of the three journals and the doctoral dissertations separately.

Statistical reasoning was the most frequent topic covered in the *SERJ* and the doctoral dissertations. The fact that almost half (48%) of the articles in the *SERJ* and more than half (63%) of the doctoral dissertations were about statistical reasoning indicates a great interest in this topic. Topics that emerged from the doctoral dissertations in this regard are, for example "How do college students reason about hypothesis testing in introductory statistics courses?", "Investigating elementary school students' reasoning about distributions in various chance events", "A longitudinal investigation of the development of College students' reasoning about bivariate data during an introductory statistics course", and "Statistics students' reasoning when comparing distributions of data". The fact that the *SERJ* aims to publish high quality research and that doctoral dissertations also require high quality research was perhaps the main reason why the complex topic of statistical reasoning appears most frequently in the two sources.

The majority of the articles in both the *JSE* and *Teaching Statistics* covered the topic of Teaching and learning; 40% of the articles in the *JSE* and 47% of the articles in *Teaching Statistics* examined this topic. The aim of these two journals is to publish articles on teaching statistics as a specialist subject, which may explain the high prevalence of the topic of Teaching and learning. We also note that the second most frequent topics in both journals were Computer use and Course design.

While the three journals may be open to publishing articles on most aspects of statistics education, researchers working on particular themes should be able to get a good idea of the most likely journals to target.

TABLE 2
Frequency of topics covered by each source

	SERJ	**JSE**	**Teaching Statistics**	**Doctoral Dissertations**
Teaching and learning	6	32	7	2
Non-cognitive factors	4	8	0	5
Statistical reasoning	20	4	1	15
Computer use	4	14	4	2
Course design	2	15	3	0
Non-empirical studies	6	8	0	0
Total	**42**	**81**	**15**	**24**

Discussion of Results

In this section the results are discussed according to the different categories identified (see Table 1).

Teaching and Learning

Teaching and learning was the most common topic category. It appeared in about 29% of the documents, and within this category the most common topic was teaching activities, followed by teaching strategies. Writing exercises and the use of real data were mentioned or investigated in only a few studies.

Of the 47 documents coded as pertaining to teaching and learning, 25 (about 53%) described teaching activities. More than half of the activity studies dealt with games (8 studies) and projects (6 studies). Some interesting games emerged from the studies.

Andrews (2005) presents a rich data set from the game of Ultimate to demonstrate hypothesis testing, Markov chains and logistic regression. Students can perform different types of analysis on the data as in-class activities. Sorto & White (2008) use the Gumball game activity to give students the opportunity to explore and discuss the variation which occurs in sampling, and Stephenson, Richardson, Gabrosek & Reishman (2009) describe an interactive activity that revolves around the diced-based golf game GOLO. This activity illustrates the binomial distribution, the sampling distribution, confidence intervals for proportions, and hypothesis tests for proportions. The remainder include a game to illustrate the technique of distance sampling, a game where students attempt to measure something they cannot see, a card game to reinforce basic statistical concepts, a game involving students attempting to toss a ball into a trash can from various distances, and a game with paper clips to learn how to collect and analyze data, and how to infer conclusions from data analysis.

Three types of projects were investigated: A few studies described research projects typical of the type encountered in statistical practice, from the formulation of a researchable question to the analysis and interpretation of the results. Gunaratna, Johnson & Stevens (2007) discussed student participation in real consulting projects to help them develop statistical consulting skills and to allow them to apply statistical concepts. They also discuss classroom material to solve real problems. Another project illustrated how doctoral students developed a follow-up survey for teacher preparation programs to help them gain the skills needed to develop sound assessment instruments.

The remaining 11 activity studies were very diverse. These activities include demonstrations, experiments and assignments.

Teaching strategies were covered in 14 research articles and in two doctoral dissertations, about 34% of the 47 documents coded as pertaining to teaching and learning, and slightly under 10% of the total. Most of these (31%) illustrated action research by teachers to improve their skills. Roback, Chance, Legler & Moore (2006) discussed the Japanese Lesson Study Principles which constitute a collaborative approach for teachers to plan, present, observe and critique classroom lessons. Through this lesson study process, teachers systematically examine both student learning and their own teaching practices. Groth (2008) gauged teachers' perceptions of GAISE (Guidelines for Assessment and Instruction in Statistics Education) which helped reveal both barriers and inroads to the implementation of GAISE recommendations in the classroom. One study reports how students identified areas of concern about their learning and how teachers and researchers identified problematic areas, while another investigated two interventions as teaching strategies to improve motivation and conceptual understanding.

Another 25% of the teaching strategy studies examined the use of group work, cooperative learning, or individualization. Three studies used visual representations (e.g. photographs and graphs) to enhance understanding and to facilitate problem solving, while the remaining articles discussed constructivism, innovation, and new illustrations in class as teaching strategies in the classroom.

Writing and the use of real data in statistics instruction have been investigated as a component of instruction only recently; all six studies of real data and writing have been conducted since 2007. Interesting datasets used for writing exercises are real stock market data, data collected for several hundred used motor cars, and atmospheric concentrations of chlorofluorocarbons.

Non-cognitive factors
Among the 17 non-cognitive studies, only five (about 30% or 3% in total) discussed or developed instruments to assess non-cognitive factors. Of these, two were doctoral dissertations. One dissertation developed and validated a scale for measuring instructors' attitude toward concept-based teaching of introductory statistics at the tertiary level (Hassad, 2007), and the other dissertation developed a Statistics Anxiety Measure (Earp, 2007). Among the research articles, an Attitude Toward Research scale was created, and The Survey of Attitudes Toward Statistics as well as the Statistical Reasoning Assessment are discussed.

Seventy percent of the non-cognitive studies investigated the role of non-cognitive factors in the learning of statistics (three of the 12 studies were doctoral dissertations). Attitudes toward statistics are covered in four (one third) of the studies (e.g., Vanhoof, Sotos, Onghena, Vershaffel, Van Dooren & Van den Noortgate, 2006). A few studies examined the effect of humor and motivational constructs, while only single studies investigated the effect of perfectionism, anxiety, gender, and race.

Statistical reasoning
Statistical reasoning was the second most prevalent topic found in the documents, namely in 25% of the sources. The documents on statistical reasoning largely focused on reasoning about a statistical concept. The high percentage of documents related to this sub-category confirms this impression (90% of the 40 documents coded as pertaining to statistical reasoning examined students' or teachers' statistical reasoning about a specific concept. More than one-third (36%) of these documents were doctoral dissertations.

Statistical variation was the most popular statistical concept investigated (10 documents), followed by statistical inference (8 documents) and probability distributions (five documents). Based on this analysis, reasoning about statistical inference has been investigated only recently; all studies on statistical inference (except for one doctoral dissertation) were conducted during 2008 and 2009. The majority of the studies on reasoning about other concepts were conducted from 2005 to 2007. The remaining concepts under investigation were diverse and include reasoning about statistical sampling (e.g., Noll, 2007), hypothesis testing (e.g., Kaplan, 2006), quantitative bivariate data (e.g., Zieffler & Garfield, 2009), and probability (e.g., Rubel, 2007).

Only 10% of the studies on statistical reasoning focused on the use and development of instruments to assess statistical reasoning. For example, delMas, Garfield, Ooms & Chance (2007) described the development of the CAOS (Comprehensive Assessment of Outcomes in Statistics) test, and Lane-Getaz (2007) developed and validated the RPASS (Reasoning about P-values and Statistical Significance) scale.

Computer use
Computer use as a category formed about 15% of the literature. Nearly half (46%) of the sources in this category concerned computer assisted instruction and its effect on student learning, understanding, and performance. Almost two-thirds (64%) of the studies in this sub-category were conducted during 2008 and 2009. It seems that JAVA Applets as a technological tool to illustrate concepts such as ANOVA, the central limit theorem, and the law of large numbers were quite popular.

A variety of aspects of computer assisted instruction were studied in the remaining 13 investigations. For example, Martin (2008) used a spreadsheet tool to illustrate F-tests, t-tests, multicollinearity and statistical power analysis, Watson (2008) used the statistics data-visualization software TinkerPlots to develop students' informal inference skills, Green (2007) developed a graph called Grapharti to facilitate insight into large amounts of data, and Ragasa (2008) determined whether there is a significant difference in achievement

between a treatment group (who made use of computer assisted instruction) and a control group (who was taught with the use of the traditional method). Only one doctoral dissertation studied computer assisted instruction and the focus was to determine whether or not various uses of technology differentially affect statistics achievement among undergraduate or graduate students (Schenker, 2007).

Only two of the 24 references (8%) coded as pertaining to computer use discussed and examined new statistical software. Brooks & Raffle (2005) described the Friendly Introductory Statistics help (FISH) computer program which is an easy-to-use software designed to help students learn introductory statistical concepts, and Hunt (2007) described a new software tool called ISCUS (Individualized Statistics Coursework Using Spreadsheets) which facilitates the setting and marking of student assignments based on a substantial set of data.

Five (21%) of the 24 references in the computer use category discussed the application or development of a simulation tool. Schneiter (2008) developed two applets to illustrate hypothesis testing through simulation, and Hagtvedt, Jones & Jones (2008) developed a simulation tool that encourages the experimentation with multiple confidence intervals derived from the same population. A few studies discussed simulation tools for the generation of various probability distributions.

Furthermore, one-quarter (25%) of the references in the computer use category studied online instruction, including web-based instruction, an online tutoring system, and the use of electronic textbooks ActiveStats and CyberStats as a web-enhanced version of the undergraduate statistical course.

Course design

Course design formed a rather small segment (12%) of the literature and no doctoral dissertation was included in this category. More than a third (35%) of the sources in this category described changes and initiatives to freshen up the typical undergraduate courses, the design/redesign of a course, course revision, as well as the development of new course materials (e.g., Marriott, Davies & Gibson, 2009).

One-fifth (20%) of the studies on course design investigated the incorporation of service-learning in statistics courses. For example, a student-run consulting program that has been serving its local community can be considered as a service-learning component of the course. Hydorn (2007) presented different models for incorporating service-learning in statistics courses and other authors identified and evaluated appropriate projects for service-learning or explored advantages of assigning a service-learning project.

Three articles discussed the development of a biostatistical course and another three articles explored students' quantitative literacy (mathematical skills) and argued for an across-the-curriculum approach to teaching quantitative reasoning (e.g., Jordan & Haines, 2006).

Non-empirical studies

Non-empirical studies formed the smallest segment of the literature. Across the 162 references, only 14 studies (9%) were coded as non-empirical. Although these articles did not provide empirical data, they still provide a wealth of ideas for developing statistical reasoning, improving student experience, and reducing misconceptions about statistical concepts. Three articles (e.g., Pfannkuch, 2005) discussed students' reasoning about variation and variability and provided possible instructional goals as well as types of assessment tasks to improve the students' reasoning. Two articles discussed students class preferences, their preferred teaching style, and their overall experience taking introductory statistics and another two performed textbook evaluations. Among the textbook evaluations, one study carried out a content analysis of the topics dealing with probability in

a sample of textbooks aimed at pupils in secondary education, and another analyzed tasks, exercises and activities that contain probability within middle grades mathematics textbooks. Only one article was a literature review on the teaching and learning of introductory statistics at university level.

The remaining articles discussed topics as diverse as statistical terms and their misleading impressions, the value of possessing quantitative skills to increase student confidence, misconceptions about hypothesis tests, and methods to assess structural knowledge.

Conclusions

In this article the authors outline the major themes and topics of 138 research articles and 24 doctoral dissertations. Research studies related to statistics education published in conference proceedings and articles related to the teaching and learning of statistics published in journals from other disciplines are not included in this study. However, the selected journals can be regarded as among the most influential in statistics education and reflect and represent contemporary trends in the field.

The most notable finding is that the topic of teaching and learning of statistics seems to be very popular among researchers in the field (see Table 1), perhaps because of the large numbers of students who enroll in introductory statistics courses as a requirement for their degree programs. The numerous teaching activities and strategies investigated and described in the literature support this belief. Furthermore, the teaching and learning articles indicate the students' difficulties students with learning statistics and the need to revise traditional methods of teaching. Experiences with real data are emphasized which leading to an increased demand for interesting data sets and examples.

Another significant finding of the study is the growing network of researchers interested in studying the development of students' statistical reasoning. The statistical reasoning articles reflected the shift in emphasis in statistics instruction: instead of focusing on procedural understanding (formulas, computations and procedures), the emphasis is rather on the development of conceptual understanding and statistical reasoning. These articles also suggest that good reasoning about important statistical concepts can be developed by using activities and tools, given enough time and revisiting of these ideas. Both quantitative and qualitative methods of assessment have been used to study students' reasoning abilities. However, only a few quantitative instruments are available for the assessment of statistical reasoning. More validated instruments are certainly needed to assess statistical reasoning.

The research on non-cognitive factors provides evidence supporting the effect of non-cognitive factors in learning statistics. Studies not only investigated students' attitudes and anxiety about statistics, or the effect of humor, motivational constructs, perfectionism and gender, but also investigated its influence on their performance in a statistics course. Unfortunately, only a few instruments to assess non-cognitive factors were discussed. The non-cognitive studies also reflected a great variation in students' expectations and perceptions of what statistics is about.

With the abundance of technology now available for use in teaching statistics, it came as a surprise that only a few articles were dedicated to this topic. The small number of articles that discussed and examined new statistical software was also disappointing. More recent studies of computer use have examined the use of computer assisted instruction and its effect on student learning and performance. The studies reflect the popularity of JAVA Applets and simulation tools to illustrate statistical concepts.

Course design and non-empirical studies formed rather small segments of the literature. The studies on course design strongly suggest the incorporation of service-learning in statistics courses. The 24 doctoral dissertations represent statistics education matters such as the learning, teaching, and assessment of statistical methods or statistical thinking and reasoning.

The implications of this analysis for statistics education research are as follows: First, examining these themes revealed the emphases in statistics education research as well as the areas in need for future study. Second, it offers an improved framework for understanding the development and patterning of statistics education research. Third, it creates some order in the field of study by providing an overview of the current themes/topics of statistics education research. Fourth, the background given on the nature of the research in statistics education van serve as a valuable resource for current researchers in the field and will make it easier for or stimulate new researchers to become involved in researching their own practices in the field. Overall, the article can be regarded as an attempt to advance the scholarship of teaching and learning in the pure disciplines.

References

Andrews, C. (2005). The Ultimate Flow. *Journal of Statistics Education, 13*(1). http://www.amstat.org/publications/jse/v13n1/andrews.html

Becker, J. (1996). A Look at the Literature (and Other Resources) on Teaching Statistics. *Journal of Educational and Behavioral Statistics, 21*(1), 71-90.

Bitzer, E.M. (2006). Restoring the status of teaching scholarship at a research-oriented university. *South African Journal of Higher Education, 20*(4), 372-390.

Boyer, E.L. (1990). *Scholarship Reconsidered: Priorities of the Professoriate*. San Francisco: Jossey-Bass Inc.

Brooks, G.P. & Raffle, H. (2005). FISH: A new computer program for friendly introductory statistics help. *Teaching Statistics, 27*(3), 81-88.

delMas, R., Garfield, J., Ooms, A. & Chance, B. (2007). Assessing students' conceptual understanding after a first course in statistics. *Statistics Education Research Journal, 6*(2), 28-58.

Earp, M.S. (2007). Development and validation of the statistics anxiety measure. (Unpublished Ph.D. thesis.) Portland State University, Oregon.

Elton, L. (2008). Recognition and Acceptance of the Scholarship of Teaching and Learning. *International Journal for the Scholarship of Teaching and Learning, 2*(1), 2-5.

Garfield, J. & Ben-Zvi, D. (2007). How Students Learn Statistics Revisited: A Current Review of Research on Teaching and Learning Statistics. *International Statistical Review, 75*(3), 372-396.

Green, H. (2007). Grapharti: A new visual summary of data. *Journal of Statistics Education, 15*(3). http://www.amstat.org/publications/jse/v15n3/green.html

Groth, R.E. (2008). Assessing teachers' discourse about the pre-K-12 guidelines for assessment and instruction in statistics education (GAISE). *Statistics Education Research Journal, 7*(1), 16-39.

Gunaratna, N.S., Johnson, C.A. & Stevens, J.R. (2007). Service-learning for graduate students through a student-run consulting program. *Journal of Statistics Education, 15*(2). http://www.amstat.org/publications/jse/v15n2/gunaratna.html

Hagtvedt, R., Jones, G.T. & Jones, K. (2008). Teaching confidence intervals using simulation. *Teaching Statistics, 30*(2), 53-56.

Hassad, R.A. (2007). Development and validation of a scale for measuring instructors' attitudes toward concept-based or reform-oriented teaching of introductory statistics in the health and Behavioral Science. (Unpublished Ph.D. thesis.) Touro University International, Cypress.

Hunt, N. (2007). Individualized statistics coursework using spreadsheets. *Teaching Statistics, 29*(2), 38-43.

Hydorn, D.L. (2007). Community service-learning in statistics: Course design and assessment. *Journal of Statistics Education, 15*(2). http://www.amstat.org/publications/jse/v15n2/hydorn.html

Jordan, J. & Haines, B. (2006). The role of statistics educators in the quantitative literacy movement. *Journal of Statistics Education, 14*(2). http://www.amstat.org/publications/jse/v14n2/jordan.html

Kaplan, J.J. (2006). Factors in statistics learning: Developing a dispositional attribution model to describe differences in the development of statistical proficiency. (Unpublished Ph.D. thesis.) University of Texas, Austin.

Kreber, C. (2005). The scholarship of teaching and learning. *Centre for Teaching, Learning and Assessment*. http://www.tla.ed.ac.uk/centre/scolarship.htm

Lane-Getaz, S.J. (2007). Development and validation of a research-based assessment: Reasoning about p-values and statistical significance. (Unpublished Ph.D. thesis.) University of Minnesota, Minneapolis.

Maree, K. (2007). *First Steps in Research*. Pretoria: Van Schaik Publishers.

Marriott, J.M., Davies, N. & Gibson, L. (2009). Teaching, learning, and assessing statistical problem solving. *Journal of Statistics Education, 17*(1). http://www.amstat.org/publications/jse/v17n1/marriott.html

Martin, D. (2008). A spreadsheet tool for learning the multiple regression-test, t-tests, and multicollinearity. *Journal of Statistics Education, 16*(3). http://www.amstat.org/publications/jse/v16n3/martin.html

Noll, J. (2007). Graduate teaching assistants' statistical knowledge for teaching. (Unpublished Ph.D. thesis.) Portland State University, Portland.

Pfannkuch, M. (2005). Thinking tools and variation. *Statistics Education Research Journal 4*(1) 83-91.

Ragasa, C.Y. (2008). A comparison of computer-assisted instruction and the traditional method of teaching basic statistics. *Journal of Statistics Education, 16*(1). http://www.amstat.org/publications/jse/v16n1/ragasa.html

Roback, P., Chance, B., Legler, J. & Moore, T. (2006). Applying Japanese Lesson Study Principles to an upper-level undergraduate statistics course. *Journal of Statistics Education, 14(*2). http://www.amstat.org/publications/jse/v14n2/roback.html
Rubel, L.H. (2007). The availability heuristic: A redux. *Journal of Statistics Education, 15*(2). http://www.amstat.org/publications/jse/v15n2/rubel.html

Schenker, J.D. (2007). The effectiveness of technology use in statistics instruction in higher education: A meta-analysis using hierarchical linear modeling. (Unpublished Ph.D. thesis.) Kent State University, Ohio.

Schneiter, K. (2008). Two Applets for teaching hypothesis testing. *Journal of Statistics Education, 16*(3). http://www.amstat.org/publications/jse/v16n3/.schneiter.html

Sorto, M.A. & White, A. (2008). The gumball machine: Linking research and practice about the concept of variability. *Journal of Statistics Education, 16*(2). http://www.amstat.org/publications/jse/v16n2/white.html

Stemler, S. (2001). An Overview of Content Analysis. *Practical Assessment, Research & Evaluation, 7*(17). http://PAREonline.net/getvn.asp?v=7&n=17

Stephenson, P., Richardson, M., Gabrosek, J. & Reiscman, D. (2009). How LO can you GO? Using the diced-based golf game GOLO to illustrate inferences on proportions and discrete probability distributions. *Journal of Statistics Education, 17*(2). http://www.amstat.org/publications/jse/v17n2/stephenson.html

Trigwell, K. & Shale, S. (2004). Student learning and the scholarship of university teaching. *Studies in Higher Education, 29*(4), 523-536.

Tull, A & Miller, M.T. (2009). Highways and Byways: The Career Paths of Senior Student Affairs Officers. *Education Resources Information Center (ERIC)*. http://eric.ed.gov/ED505887.htm

Vanhoof, S., Sotos, A.E., Onghena, P., Verschaffel, L., Van Dooren, W. & Van den Noortgate, W. 2006. Attitudes toward statistics and their relationship with short- and long-term exam results. *Journal of Statistics Education, 14*(3). http://www.amstat.org/publications/jse/v14n3/vanhoof.html

Watson, J.M. (2008). Exploring beginning inference with novice grade 7 students. *Statistics Education Research Journal, 7*(2), 59-82.

Weston, C.B. & McAlpine, L. (2001). Making explicit the development toward the scholarship of teaching. In *Scholarship revisited: Perspectives on the scholarship of teaching*, edited by C. Kreber. San Francisco: Jossey-Bass.

Zieffler, A., Garfield, J., Alt, S., Dupuis, D., Holleque, K. & Chang, B. (2008). What Does Research Suggests About the Teaching and Learning of Introductory Statistics at the College Level? A Review of the Literature. *Journal of Statistics Education, 16*(2). http://www.amstat.org/publications/jse/v16n2/zieffler.html

Zieffler, A. & Garfield, J.B. (2009). Modeling the growth of students' covariational reasoning during an introductory statistics course. *Statistics Education Research Journal, 8*(1), 7-31.