RIGOR IN AGRICULTURAL EDUCATION RESEARCH REPORTING: IMPLICATIONS FOR THE DISCIPLINE

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Abstract

Agricultural education has been criticized for publishing research lacking many of the rigorous qualities found in publications of other disciplines. A few agricultural education researchers have suggested strategies for improving the rigor with which agricultural education studies report on methods and findings. The purpose of this study was to determine whether studies in agricultural education have followed the methodological suggestions proposed by these select researchers. Every study published in the Journal of Agricultural Education between 2000 and 2006 (N = 244) was examined using content analysis techniques. Specifically, quantitative, inferential studies were assessed with regard to the conveyance of practical significance, the stating of research hypotheses, and explicitly acknowledging how statistical assumptions were addressed and confirmed. Of the 88 inferential studies published in the Journal since 2000, 52% did not convey the practical significance of their research findings and 74% did not explicitly state research hypotheses. Nearly 80% did not acknowledge how the assumptions associated with statistical tests used were addressed and confirmed. Studies that conveyed practical significance, stated hypotheses, and addressed statistical assumptions are cited as examples to follow. Perhaps an increase in pages allotted to each article would provide authors with adequate space to report such items.

Introduction/Literature Review

The character of a room can be judged by the layout of the pictures on its walls. Similarly, the character of a discipline can be judged by the layout of its research (Williams, 1991). The discipline of agricultural education has been criticized for publishing research which lacks many of the rigorous qualities found in the publications of other disciplines (Buriak & Shinn, 1989; Dyer, Haase-Wittler, & Washburn, 2003). Considering each picture on the wall of a room analogous with an individual research study might provide some guidance on what our discipline could do to improve its image among similar fields. Although the content of the pictures may vary widely, just as the content of research studies in our discipline varies, the steps each photographer took from snapshot to photograph development should be quite similar. In this sense, researchers are much like photographers, taking snapshots of phenomena and following a series of iterative steps to "develop" their ideas into pieces of knowledge that add character to a discipline.

From a methodological standpoint, an understanding of the consistency with which such steps have been followed may provide insight as to why agricultural education research has been viewed as less rigorous than other fields. In fact, some researchers in the discipline (most notably Miller, 1994, 1998, 2006) have strongly advocated that researchers follow specific guidelines during the measurement, analysis, and reporting phases of their studies. In a sense, Miller (1994, 1998, 2006) advocated that the steps taken to "hang our pictures" are consistent across studies. However, have studies in agricultural education followed the

methodological suggestions proposed by Miller and others? This paper will attempt to answer that question via a "snapshot" of research published in the *Journal of Agricultural Education* since 2000.

Wagner (1993) defined research as a strategy for reducing ignorance and advocated that educational research reporting is a form of teaching. As such, in the same way agricultural education instructors discuss the theoretical and pedagogical assumptions grounding their classroom lessons, it seems that the way in which we report our findings should mirror the format of our lesson plans. In a sense, if research is to be replicated, one must know relevant background information, objectives to be achieved, materials needed, and the specific procedures (methods) used to accomplish established objectives. However, have we become so excited to report our findings (or jump to the evaluation exercise in our lesson plan) that we forget to also teach our research methods (or let our learners experience lesson activities) to the reader?

It is important to consider the clarity with which we report our research findings, but others advocate that the clarity and consistency with which our research methods are reported is just as important. Referring back to the lesson plan analogy, how could a teacher replicate a lesson without step-by-step instructions detailing the procedures to use? In fact, Miller (1994, 1998, 2006) has suggested for quite some time that research in the agricultural education discipline lacks clear, rigorous documentation of the measurement and analysis procedures used to arrive at the reported findings—from research hypotheses to practical significance. For example, Miller (1994, 1998) suggested that researchers in agricultural education do not explicitly (in writing) state how their analysis process initiated, specifically (a) the null and alternative hypotheses and (b) how assumptions associated with the statistical tests used during the analysis were addressed and confirmed.

In essence, if one was to develop a lesson on how to properly hang a picture on a wall, his/her lesson plan would surely contain (a) a description of the process to determine where to hang the picture (hypotheses and assumptions) and (b) how to determine that the location chosen will support the weight of the picture and frame (checking and confirming assumptions). This might include a description of the "tools" used to check these assumptions (such as a stud finder, hammer, and level), just like Levene's test is used to ensure homogeneity of variance in a regression analysis. In addition, Miller (1994) suggested that although studies in agricultural education are using inferential statistics, they are not addressing the practical (compared to statistical) significance of their research findings and that doing so will improve the utility of the discipline's research findings. This would imply that for every inferential statistical procedure used, the percentage of variability explained should be reported.

Others echo the importance of addressing the practical significance of research findings when inferential statistics are used. Williams (1991) suggested that the discipline's research reporting techniques must have applied applications so as to help promote partnerships with agencies and industry and potentially facilitate dissemination and implementation of research findings. Specifically, Miller (1994) suggested squaring the Pearson correlation coefficient to get at practical significance. Agresti (1996) advised that social science researchers analyzing categorical data compare odds ratios to determine practical significance. Agresti and Finlay (1997) suggest that social science researchers use confidence intervals more often to convey the practical significance of research findings. For example, instead of stating whether there was a significant difference in the mean amount of time that males and females watched television (as could be indicated with an independent samples *t*-test), they advocate reporting *how* different a similar population would likely be in their mean television watching time with a confidence interval. Miller (1998) suggested that researchers address practical significance by calculating and reporting omega-squared or eta-squared coefficients. Finally, Ary, Jacobs, Razavieh, and Sorensen (2006) suggest reporting effect

size to assess the magnitude of difference between two or more groups and convey practical significance to the research consumer. That is, in the same way teachers answer the "so what?" question at the conclusion of a lesson plan with recommended application/ extension activities, researchers should answer the practical significance question of their study findings.

Miller (1998) spoke specifically with regard to data analysis procedures in conveying the practical significance of agricultural education research results to the research consumer. He advocated that although complicated statistical procedures often seem to be preferred in agricultural education research, such procedures "do not make something scientific or important" (Miller, 1998, p. 8). The practical significance of the questions researchers ask must not be masked by "glamorous" analysis procedures. More recently, Miller (2006) spoke to the practical ability of our research findings, stating "researchers in agricultural education must become better able to articulate their possible contributions to the research missions of a college and communicate clearly and persuasively" (p. 114).

Miller (1998) suggested that the *Journal* be used as a forum to discuss issues such as determining the practical significance of research findings and ensuring that data analysis procedures are appropriately applied, given research hypotheses and statistical assumptions (e.g., normality, linearity, homoscedasticity). As the premier refereed publication in agricultural education, the authors wished to determine the extent to which studies in the *Journal* have followed the suggestions that Miller (1994, 1998, 2006) and others have been making for over a decade.

Purpose and Research Questions

The purpose of this study was to determine the rigor in agricultural education research reporting in the *Journal* since 2000. Given the suggestions proposed by Miller (1994, 1998, 2006) and others, the following four questions guided this work:

1. What type of articles and how many of each type have been published in the *Journal* since 2000?
2. To what extent have quantitative studies published in the *Journal* that use inferential statistics conveyed the practical significance of their research findings?
3. When necessary, to what extent have such studies explicitly stated research hypotheses?
4. To what extent have such studies explicitly stated how the assumptions associated with statistical tests were addressed and confirmed?

Methods and Procedures

To measure whether studies in agricultural education have followed the suggestions proposed by Miller and others, and continuing with the lesson plan analogy, the lead author developed a rubric to score each study reviewed. The rubric allowed the author to compare the type of article published with whether (yes/no) and to what extent practical significance, research hypotheses, and statistical assumptions were conveyed. Every study published in the *Journal* between 2000 and 2006 (N = 244, not including seven distinguished lectures) was examined using content analysis techniques in an attempt to answer the first research question. However, studies using quantitative methods were more thoroughly examined in an attempt to answer Research Questions 2, 3, and 4. Only the lead author reviewed all studies to enhance the reliability of how each article was evaluated and eliminate inter-rater reliability issues. When reviewing studies, "rigor" in terms of research reporting was operationally defined as the ability of an article to appropriately convey practical significance, research hypotheses, and associated statistical assumptions.

With more than 83% of the studies published in the *Journal* between 1990 and 1999 being classified as quantitative in nature (Dyer et al., 2003), the authors posited that the majority of studies published between 2000 and 2006 would also be quantitatively based. Studies using mixed

methods (qualitative and quantitative techniques) were examined with the same rigor as those using only quantitative methods because both descriptive and inferential statistics can be used in such studies. Qualitative pieces, syntheses of literature, historical analyses, and philosophical papers were not examined when addressing Research Questions 2, 3, and 4. Data were analyzed using the Statistical Package for the Social Sciences (SPSS version 14.0). Descriptive statistics, including frequencies, percentages, and crosstabs were used to summarize data.

Results/Findings

Question 1: What type of articles and how many of each type have been published in the Journal since 2000?

Of the 251 pieces published in the *Journal* since 2000, 66% (n = 165) could be classified as exclusively quantitative in nature (Table 1). These included studies using either descriptive statistics only or both descriptive and inferential statistics. More articles using inferential statistics were published in the *Journal* than any other article type. In general, the number of studies using inferential statistics has increased, and, with the exception of 2005, the number of studies using only descriptive statistics has decreased since 2000.

With the exception of 2005, in which the proportion of exclusively descriptive and descriptive and inferential studies published was about equal, the proportion of studies using inferential statistics has been greater than the proportion using descriptive statistics only since 2000. Although the majority of the studies published in 2000 used only descriptive statistics, they were primarily census studies.

Table 1
Comparison of Types of Articles Published in the Journal of Agricultural Education Between 2000 and 2006 (N = 251)

	2000		2001		2002		2003		2004		2005		2006			
Article type	*f*	%	*f*	%	*f*	%	*f*	%	*f*	%	*f*	%	*f*	%	Total	%
Descriptive	26	59.1	8	26.7	8	26.7	7	20.0	7	20.0	13	38.2	8	18.6	77	30.7
Descriptive and inferential	8	18.2	10	33.3	14	46.7	11	31.4	15	42.9	12	35.3	18	41.9	88	35.1
Qualitative	4	9.1	7	23.3	4	13.3	6	17.1	4	11.4	1	2.9	7	16.3	33	13.1
Mixed methods	4	9.1	2	6.7	2	6.7	2	5.7	3	8.6	3	8.8	1	2.3	17	6.8
Delphi study	0	0	0	0	0	0	5	14.3	1	2.9	3	8.8	4	9.3	13	5.2
Synthesis of literature	1	2.3	0	0	0	0	1	2.9	2	5.7	1	2.9	2	4.7	7	2.8
Historical research	0	0	1	3.3	1	3.3	1	2.9	1	2.9	0	0	1	2.3	5	2.0
Philosophical	0	0	1	3.3	0	0	1	2.9	1	2.9	0	0	1	2.3	4	1.6
Distinguished lecture	1	2.3	1	3.3	1	3.3	1	2.9	1	2.9	1	2.9	1	2.3	7	2.8
Total	44	100	30	100	30	100	35	100	35	100	34	100	43	100	251	100

Question 2: To what extent have quantitative studies published in the Journal that use inferential statistics conveyed the practical significance of their research findings?

Of the 165 quantitative studies published in the *Journal* since 2000, only those studies using inferential statistics (n = 88) were examined to answer Research Question 2. It should be noted that three of the studies using mixed methods used inferential statistics (including t-tests, analysis of covariance, and multiple regression). These three studies were not included in this analysis because they were not purely inferential. All other mixed methods studies used descriptive statistics only to summarize the data.

Of the 88 inferential studies published in the *Journal* since 2000, 52% (n = 46) did not convey the practical significance of their research findings (Table 2). Although the manuscript submission guidelines for the *Journal* request that authors report effect sizes, a way to demonstrate practical significance of findings (Ary et al., 2006; Miller, 1998), only 42 inferential studies did so. The most commonly reported form of practical significance was the R-squared term, followed by the squaring of the Pearson correlation coefficient r. Confidence intervals and standard error terms were reported least often. Although the number of studies using inferential statistics generally increased between 2000 and 2006, examining the reporting of practical significance over these 7 years revealed no related trends. Readers are encouraged to refer to Roberts and Dyer (2005) as an example of an article that accurately reported practical significance.

Question 3: When necessary, to what extent have inferential studies reported in the Journal explicitly state research hypotheses?

Of the 88 inferential studies published in the *Journal* since 2000, 74% (n = 65) did not explicitly state research hypotheses (Table 3). An examination of the data reveals that although the number of inferential studies that were published between 2000 and 2006 increased, fewer inferential studies explicitly stated research hypotheses over this time period.

Question 4: To what extent have inferential studies reported in the Journal explicitly stated how the assumptions associated with statistical tests were addressed and confirmed?

Of those same 88 inferential studies published in the *Journal* since 2000, nearly 80% (n = 70) did not explicitly report how the assumptions associated with the statistical tests used were addressed and confirmed (Table 4). On examining the data, fewer than half the inferential studies published each year between 2000 and 2006 stated outright how the assumptions associated with the inferential statistics used were accounted for. Readers are encouraged to refer to Pense and Leising (2004) as an example of how to report the procedures for addressing and confirming statistical assumptions.

Table 2
Number of Inferential Studies Published in the Journal that Reported Practical Significance of Research Findings (n = 88)

Practical significance explicitly conveyed?	2000	2001	2002	2003	2004	2005	2006	Total
Yes	4	3	9	2	8	6	10	42
No	4	7	5	9	7	6	8	46
Total inferential studies	8	10	14	11	15	12	18	88

Table 3
Number of Inferential Studies Published in the Journal that Explicitly Stated Research Hypotheses (n = 88)

Research hypotheses explicitly stated?	2000	2001	2002	2003	2004	2005	2006	Total
Yes	1	1	5	3	3	4	6	23
No	7	9	9	8	12	8	12	65
Total inferential studies	8	10	14	11	15	12	18	88

Table 4
Number of Inferential Studies Published in the Journal Explicitly Stating How the Assumptions Associated with Statistical Tests Used Were Addressed and Confirmed (n = 88)

Statistical assumptions explicitly addressed?	2000	2001	2002	2003	2004	2005	2006	Total
Yes	1	0	4	1	6	2	4	18
No	7	10	10	10	9	10	14	70
Total inferential studies	8	10	14	11	15	12	18	88

Discussion

Research Question 1 examined the types of articles published in the *Journal* and the frequency of article types published since 2000. In general, the proportion of studies using inferential statistics has been greater than the proportion using descriptive statistics only since 2000. However, in 2000, the majority of studies published in the *Journal* used descriptive statistics only, a value twice as high as the number of descriptive studies published in all other years. In describing the number and types of articles published in the *Journal of Agricultural Education* between 1990 and 1999, Lindner, Murphy, and Briers (2001) found that about 44% of the articles reporting sampling procedures were census studies. In this study, the majority of studies published in 2000 were census studies and used descriptive statistics (describing parameters) because inferential statistics are not warranted when a census is attainable. Thus, 2001 represents a year of substantial change in the number of inferential studies being published in the *Journal*, a trend that has continued for over 5 years.

Research Questions 2, 3, and 4 were developed based on suggestions of Miller and others and referred to the rigor with which studies in agricultural education have documented research methods and findings. Research Question 2 examined the extent that studies using inferential statistics conveyed the practical significance of research findings. Of those studies reporting practical significance, one of the most frequently reported forms of practical significance (over reporting the R-squared term in regression analysis) was squaring of the Pearson correlation coefficient. Miller (1994, 1998) advocated for more authors using relational statistics such as correlations to square the correlation coefficient to describe the amount of variability in the dependent variable which is explained by having knowledge of an independent variable. Perhaps this form of practical significance reporting was garnered following Miller's suggestions.

Research Question 3 examined the extent to which inferential studies explicitly stated research hypotheses. Although Miller (1994, 1998) advocated that researchers in agricultural education outright state their hypotheses as part of the scientific method, space limitations in the *Journal* may prevent such reporting. As Dyer et al. (2003) suggested, current page limits may negatively affect the ability of authors to adequately address suggestions proposed to enhance the rigor of the discipline's research reporting, such as the explicit reporting of hypotheses. Perhaps authors of inferential studies published in the *Journal* desire to report research hypotheses, thus adhering to the suggestions proposed by Miller and others, but are not given adequate space to do so. This study found that although the majority of inferential articles published in the *Journal* between 2000 and 2006 provided an adequate review of literature and study rationale, many of which "hinted" at what was to be expected in the data, few studies stated outright the research hypotheses built from the associated literature review.

Finally, Research Question 4 examined the extent to which inferential studies published in the *Journal* explicitly stated how the assumptions associated with statistical tests used were addressed and confirmed. Although the majority of inferential studies failed to discuss the assumptions upon which the statistical tests used were founded, as Dyer et al. (2003) discussed, space limitations in published manuscripts may be one reason for this. Miller (1994) argued that perhaps journal reviewers/editors will only accept articles that are "significant" or where something "significant" has been found. However, when writers omit stating how the assumptions behind the statistical tests they used were addressed and confirmed, might this imply shotgun empiricism—the unwarranted use of statistical tests in an attempt to find statistical significance—and, as Miller (1994) suggests, increase the likelihood of publication?

Considering how one might develop a lesson plan on the steps to hanging a picture on a wall might be useful in conveying the importance of explicitly stating how statistical assumptions are dealt with. For example, a properly written lesson plan on hanging a framed picture would provide a list of materials needed to accomplish the task and a statement about the setting where the task should occur (assumptions about where the lesson plan is most relevant). One could use a large mallet to secure a rusty nail into the wall of a barn to hang a picture, but a more delicate, smaller hammer and cleaner nail would likely be more desirable for hanging a picture in a fine restaurant. Without a statement of assumptions regarding materials available and the most appropriate setting for learning to occur, a teacher might use the lesson plan in a way different from how its author intended it to be used and experience complications. Similarly, if inferential studies published in the *Journal* do not explicitly state how the assumptions associated with statistical tests were addressed, readers might use findings of such studies in a way different from how the author(s) intended them to be used.

Conclusions/Recommendations

Just more than 35% of the studies published in the *Journal* between 2000 and 2006 used inferential statistics; the majority of these did not convey the practical significance of their findings, explicitly state research hypotheses, or document how the assumptions associated with the inferential statistics used were addressed. An examination of those 88 inferential studies revealed that only 6.8% (n = 6) answered Miller's (1994, 1998, 2006) suggestions and conveyed practical significance, stated hypotheses, *and* addressed statistical assumptions in the same manuscript (Table 5).

Table 5
Comparison of Reporting of Practical Significance, Research Hypotheses, and Statistical Assumptions in Inferential Studies Published in the Journal (n = 88)

	2000	2001	2002	2003	2004	2005	2006		
Research reporting done	*f*	*f*	*f*	*f*	*f*	*f*	*f*	Total	*%*
Neither P, H, or A	4	6	3	6	4	5	7	35	39.8
P only	2	3	4	1	4	3	2	19	21.6
H only	0	1	1	2	1	1	1	7	8.0
A only	0	0	0	1	2	0	0	3	3.4
P and H only	1	0	2	1	0	1	4	9	10.2
P and A only	1	0	2	0	2	0	3	8	9.1
H and A only	0	0	1	0	0	0	0	1	1.1
P, H, and A	0	0	1	0	2	2	1	6	6.8
Total	8	10	14	11	15	12	18	88	100

Note. P = Practical significance conveyed, H = Hypotheses stated, A = Assumptions regarding statistics addressed.

In the same way educators are often encouraged to examine and follow exemplary lesson plans in an effort to enhance their teaching, the authors recommend that agricultural education researchers use inferential studies that conveyed practical significance, stated hypotheses, *and* addressed statistical assumptions as an example when developing inferential studies in the future. The authors randomly selected one of these exemplary studies published in the *Journal* and have reported it here: Pate, Wardlow, and Johnson (2004).

In considering the suggestions proposed by Miller and the findings of this study, the authors make the following additional recommendations:

1. As Dyer et al. (2003) suggested, an increase in the number of pages allotted to each article would provide authors of inferential studies with additional space to report research hypotheses and discuss how statistical assumptions were addressed.
2. When adequate time and resources are unavailable to conduct census studies, researchers should consider gathering a smaller, representative sample and using inferential statistics to make predictions about the population of interest.
3. To improve the image of agricultural education research, described earlier as being of lacking quality (Buriak & Shinn, 1989; Dyer et al., 2003), authors of inferential studies in agricultural education are encouraged to explicitly state research hypotheses, explicitly address assumptions of the statistical tests they use, and consider the practical versus statistical significance of research findings. Individuals who teach statistics/ research methods courses and/or

advise agricultural education graduate students should encourage the same of their students.

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