

**To cite this article:** Zadrozny, J.; McClure, C.; Lee, J.; Jo, I. (2016). Designs, Techniques, and Reporting Strategies in Geography Education: A Review of Research Methods. *RIGEO*, 6(3), 216-233. Retrieved from <http://www.rigeo.org/vol6no3/Number3winter/RIGEO-V6-N3-1.pdf>

Submitted: July 26, 2016

Revised: November 7, 2016

Accepted: November 25, 2016

## **Designs, Techniques, and Reporting Strategies in Geography Education: A Review of Research Methods**

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### Abstract

A wide variety of research is being completed and published in geography education. The purpose of this article is to provide a general overview of the different types of methodologies, research designs, and techniques used by geography education researchers. Analyzing three geography education journals, we found 191 research articles published about geography education, of which, 55 used a quantitative design, 65 used a qualitative design, and 71 used mixed methods. This article highlights specific articles to provide examples of how a variety of quantitative, qualitative, and mixed methods techniques were conducted and presented in the literature. The implications of this article is to provide geography education researchers with guidance when reporting research results in an effort to promote replicability and longitudinal research. Geography education benefits from all types of methodological

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designs and techniques, each serving a different purpose based upon the individuals' inquires and research questions.

### Keywords

Research Design; Geography Education Research; Quantitative Research; Qualitative Research; Mixed Methods Research; Methodologies

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*A Road Map for 21<sup>st</sup> Century Geography Education: Geography Education Research* (Bednarz, Heffron, & Huynh, 2013) addressed two questions posed as charges to the research committee. Based upon these two questions, the Committee issued thirteen recommendations to improve research in geography education. The first charge dealt with areas of research that would be most effective in improving geography education at a large scale. The recommendations include examining components and characteristics of exemplary geography curricula, investigating characteristics of effective geography teaching, and more research on fieldwork, learning progressions, and teacher preparation. The second charge addressed strategies and methodologies that can be developed and adopted to maximize the impact of research in geography education. These recommendations include taking interdisciplinary and/or multidisciplinary approaches, following established principles for scientific research, and developing and studying exemplary programs, curricula, tasks, measures, and assessments to build knowledge of effective geography teaching and learning.

A way to respond to the recommendations of the Road Map, those particularly related to enhancing research effectiveness, is to systematically examine the current research practice of the field and find out specific areas for improvement, if any. A review of research methods in geography education will contribute to this by providing researchers with examples and guidelines to design research, select specific techniques for data collection and analysis, and figure out best ways to report their findings. The objectives of this review are to 1) analyze research studies in geography education in terms of research designs, specific techniques, and reporting strategies frequently adopted, and 2) provide examples of studies using those specific research methods as a future reference. Based on the findings, we also make several recommendations for improvement for research practice in geography education.

### **Research Methods in Geography Education**

Since geography is diverse in nature, geographic research is conducted in various ways. Nevertheless, the research methods used could generally be categorized into one of the three: quantitative, qualitative, or a combination of the two, called mixed methods (Gomez & Jones, 2010; Clifford, Cope, Gillespie, & French, 2016). Geography education research is particularly concerned with the teaching and learning of geography. A large assortment of research designs, data collection and data analysis methods has been employed in an attempt to uncover how students' knowledge and proficiency in geography develop and how to support the processes of learning.

Abundant research in education has focused on how students learn in the context of specific disciplines and how these research findings can contribute to improving the curriculum and instructional practice. Therefore, education research is highly relevant

for geography education, and theories and research methodologies in education provide a model for both research and practice in geography. As Cohen, Manion, and Morrison (2011) point out, though, the diverse research methods used in education follow a similar categorization to that of geography: quantitative, qualitative, and mixed methods

In this paper, we adopt Creswell's (2014) categorization and definitions for these three major research approaches for which Creswell provides concise and well-developed definitions, descriptions, and explanations to refer to. It should be noted, however, that Creswell is far from the only individual writing about research methods, nor should he be the only one on which researchers rely. An overview of each research design, including definition and specific techniques associated, is below.

### **Quantitative Research Methods**

Quantitative research is defined as "an approach for testing objective theories by examining the relationship among variables. These variables, in turn, can be measures, typically by instruments, so that numbered data can be analyzed using statistical procedures" (Creswell, 2014, p. 4). Researchers engaged in this form of inquiry are concerned with testing theories and hypotheses, controlling for alternative explanations, and ability to infer and generalize findings based on the sample results. Quantitative research encompasses a wide variety of methods, but generally the results are considered to be persuasive when researchers show statistical and/or practical significance.

In quantitative research studies, acquiring and reporting statistical significance through a null hypothesis significance testing (NHST) is the most popular way to show how much the results are worth paying attention to. Researchers build a hypothesis, set a criterion for evaluating statistical significance of the results, for example, 0.05 or 0.01, and test the hypothesis using a NHST based on observations of samples. The *p*-value calculated from the NHST is a probability of getting the observed results from the samples, given that the null hypothesis is true. It is not the probability that the hypothesis is right or wrong. Rather, *p*-value is based on the assumption that the null hypothesis is right. For example, assume that you are interested in whether there is a difference in test score means between two groups of students. Your null hypothesis is that there is no difference in mean scores between the two groups. You conducted a NHST and obtained a result with a *p*-value of 0.03. What this tells you is that your observed results are only 3% likely if the null hypothesis is true. The result ends in a decision of whether to reject or fail to reject the null hypothesis, a dichotomous outcome either 'statistically significant' or 'not statistically significant.' Because 0.03 is less than your pre-set criterion of statistical significance (0.05), you reject the null hypothesis and conclude there is a statistically significant difference in mean scores between two groups of students.

It should be noted that a result of NHST is considered significant not because it is important or meaningful, but because it has been predicted as unlikely to happen by chance alone (Sirkin, 2006). A *p*-value is an indicator to show the probability of getting the observed result, but it does not tell us how 'practically' the difference is significant or worth paying attention to. A concept related to importance and meaningfulness is

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‘practical significance,’ which measures the amount of effectiveness of the sample results (e.g., small, medium, or large effect). Effect size (ES) is a tool for showing practical significance and provides quantified information about the importance of a research result using certain metrics (Vacha-Haase, Nilsson, Reetz, Lance, & Thompson, 2000). There are many effect sizes using original units, such as a mean, difference between two means, a percentage, and correlations, as well as using a standardized value, such as Cohen’s  $d$ , a regression coefficient ( $R^2$ ), odds ratio, and eta square ( $\eta^2$ ). Cohen’s  $d$ ,  $\eta^2$ , or  $\omega^2$  would be more relevant to geography education research in relation to the quantitative methods that are frequently used in the field, such as t-test, ANOVA, and regression analysis (Kim, 2011). Effect sizes provide information to determine the importance of research results (Gravetter & Wallnau, 2008) and are useful for replication studies to compare findings from multiple studies and ultimately to accumulate knowledge (Glass, 1976; Smith & Glass, 1977; Cumming, 2006).

Meanwhile, a confidence interval (CI) is a type of interval estimation of a population parameter and is used to indicate the reliability of an estimate from samples. A CI can be formed by extending two standard errors in each direction around a point estimate. The point estimate is the middle point of the confidence interval. Positive and negative allowances on either side of the point estimate provide the margins of error. The margin of error is half the width of a confidence interval, and it indicates the precision of the confidence interval (Liu, Loudermilk, & Simpson, 2014). A confidence interval can present statistical power of the results through its width (i.e., the shorter a CI is, the stronger statistical power of the results) and offers valuable insights into the replicability of the study. Replicability of a study is important because replication can reduce the chance that the initial result was just a fluke (Cumming, 2012). CI also facilitates a meta-analysis of studies by helping comparisons of multiple studies.

NHST and  $p$ -values have been the dominant technique to analyze and report results of quantitative research in education, including geography education. However, during the last decade, scholars in education recognized limitations of NHST and  $p$ -values (Schmidt, 1996; Vacha-Haase & Thompson, 2004; Thompson, 2006; Cumming, 2012) and encourage researchers to report confidence intervals and effect sizes in addition (Wilkinson & Task Force on Statistical Inference, 1999; Cumming et al. 2007).

### **Qualitative Research Methods**

Qualitative research is “an approach for exploring and understanding the meaning individuals or groups ascribe to a social or human problem. The process of research involves emerging questions and procedures, data typically collected in the particulars to general theses, and the researcher making interpretations of the meaning of the data” (Creswell, 2014, p. 4). This form of inquiry is rather inductive and focuses on individual meaning and importance of rendering the complexity of a situation. Qualitative research is based upon an “interpretative, naturalistic approach to the world” (Denzin & Lincoln, 2013, p. 6). Qualitative research has been frowned upon because of its lack of scientific truths, but depending on the research questions and goals, qualitative research methods may be more appropriate than quantitative research methods (Denzin & Lincoln, 2013).

There are various methods and approaches considered qualitative in nature, and each provides their own significance and inquiry. Qualitative approaches allow researchers to investigate research questions in a way quantitative does not allow. They show depths and insights that can be missing from quantitative research methods and data and allow a voice for those who do not have one publically. Denzin and Lincoln (2013) illustrate a variety of qualitative research methods including, but not limited to, case studies, interviewing, participant observation, interpretive analysis, and visual methods. According to Creswell (2014) there are four basic types of collection processes: 1) observations, 2) interviews, 3) documents, and 4) audio and visual materials.

First, observation requires the researcher entering the field and taking precise and detailed descriptions of what they observe at the research site. Observational data allows a researcher to gather data in an unstructured or semi-structured way about a particular group's or subject's activities, behaviors, actions, and a host of other types of interactions, all of which are a part of the larger human experience. The researcher can engage in the role of observer in several ways: complete participant, observer as participant, participant as observer, or complete observer. Each provides a unique observation experience.

Second, interviews can be conducted face-to-face, over telephone or Skype, or as a focus group with multiple participants. Interviews follow a protocol to ensure the researcher conducts each interview the same way. Allowing open-ended questions and a semi-structured approach allows participants to discuss their views and opinions. Data gained from in-depth interviews generates direct quotes on topics, allowing for the opinions, feelings, and personal knowledge acquired from participants that have been directly involved in the particular subject or topic.

Documents are a good source of qualitative data, leading to document analysis. This consists of the process of analyzing excerpts, quotations, or passages from written documents. These types of documents can include any type of written record (organizational, program, clinical), memoranda and personal or public correspondence, personal diaries, and responses to open-ended questionnaires and surveys (Patton, 2002; Creswell, 2014). Lastly, using audio and visual materials constructs data ranging from videotapes to sound recordings, from photographs and website main pages, to text messages and social media text to name a few. There are pros and cons to each technique, making it beneficial to collect qualitative data in a variety of forms.

### **Mixed Methods Research Methods**

According to Creswell (2014), mixed methods research is conceptualized as “an approach to inquiry involving collecting both quantitative and qualitative data, integrating the two forms of data, and using distinct designs that may involve philosophical assumptions and the theoretical frameworks” (p. 4). The core assumption is that the combination of qualitative and quantitative approaches will provide a more complete understanding of a research problem than using either approach alone.

Mixed methods research has been used in various disciplines, such as health and medicine, evaluation, educational research, sociology, and psychology (Tashakkori &

Creswell, 2008), illuminating the diversity of mixed methods. Since it is a relatively new methodological approach, researchers have a different idea of what constitutes as mixed methods. If data is collected qualitatively, and then analyzed quantitatively, is it mixed methods? What if data is collected and analyzed both quantitatively and qualitatively, is that mixed methods? Or, is it mixed methods if the data is collected both ways, but only analyzed one way? The answer to these three questions is yes. No matter which way the data is collected or analyzed, the research design is mixed methods because the data is exposed to both quantitative and qualitative methodologies. Since mixed methods can be executed in various ways, Creswell and Plano Clark (2007, 2011) outlined six mixed methods designs that are commonly found in research. Creswell and Plano Clark provide an excellent, easy to understand explanation about each of these designs, so only a brief explanation of each follows.

The first design, convergent parallel, “occurs when the researcher collects and analyzes both quantitative and qualitative data during the same phase of the research process and then merges the two sets into an overall interpretation” (Creswell & Plano Clark, 2011, p.77). The second, explanatory sequential design, begins with “a quantitative phase and follows up on specific results with a second phase. The second, qualitative phase is implemented [...] to explain the initial results in more depth” (Creswell & Plano Clark, 2011, p. 82). Exploratory sequential design, the third mixed methods design, is when “the researcher starts by qualitatively exploring a topic before building to a second, quantitative phase. [...] The primary purpose [...] is to generalize qualitative findings based on a few individuals from the first phase to a larger sample gathered during the second phase” (Creswell & Plano Clark, 2011, p. 86). The fourth design, embedded, “combines the collection and analysis of both quantitative and qualitative data within a traditional quantitative research design or qualitative research design. The collection and analysis of the second data set may occur before, during, and/or after the implementation of the data collection and analysis procedures traditionally associated with the larger design” (Creswell & Plano Clark, 2011, p. 90). The fifth is transformative design, which “occurs when researchers conduct mixed methods research using a theoretical-based framework, such as a transformative worldview. [...] The purpose of this design is to conduct research that is change oriented and seeks to advance social justice causes by identifying power imbalances and empowering individuals and/or communities (Creswell & Plano Clark, 2011, p. 96). Lastly, the multiphase design occurs “when an individual researcher or team of investigators examines a problem or topic through an iteration of connected quantitative and qualitative studies that are sequentially aligned, with each new approach building on what was learned previously to address a central program objective (Creswell & Plano Clark, 2011, p. 100). Each design serves a different purpose based upon the needs of the researcher and the research questions asked.

## **Methodology**

### **Selection of Research Studies**

This study began by searching for empirical research articles through three academic geography journals that focus on the teaching and learning of geography. The three

journals selected were *Journal of Geography*, *Journal of Geography in Higher Education*, and *International Research in Geographical and Environmental Education* due to their long history of publishing articles encompassing geography education research. Following the objective of this study to analyze research studies in geography education in terms of research designs, specific techniques, and reporting strategies frequently adopted, we did not limit ourselves to a specific time frame, but instead took an exploratory approach to gather a large enough sample from each journal to review. We wanted to look at what type of research designs, data collection and analysis methods, and reporting strategies were being employed by geography education researchers, rather than what trends were apparent over a fixed time period (e.g. Bednarz, 2000). In order to get enough examples of research methodologies for our review we uncovered 60 research articles over a nine-year span (2005-early 2014) in the *Journal of Geography*; over a 15-year span (1999-early 2014), 58 research articles in the *Journal of Geography in Higher Education*; and over an eight-year span (2006-early 2014), 79 research articles were found in *International Research in Geographical and Environmental Education*. The difference in the number of research articles is due to the journals' differences in scope and publication frequency. For example, *International Research in Geographical and Environmental Education* is heavy on research articles with a publication frequency of four times a year, while *Journal of Geography* is published six times a year and includes commentaries, book reviews, and teacher resource papers. A total of 197 geography education research articles were found. However, six articles were discarded due to lack of clarity of the research design, leaving 191 research articles analyzed.

### **Coding**

To systematically identify and categorize specific research methods and procedures used in the 191 research articles, information from each article was compiled and organized into a database. Basic information, such as journal title, article title, key words, and research objectives/questions/hypotheses, were entered into the database. For research articles with human participants, information about sample size, age, grade level, gender, and geographic location, was collected. Based on the research methods described by the corresponding authors, information about the data collection and analysis procedures, statistical techniques, instruments, and other materials used, was also extracted from the articles and entered into the database. A summary of each article was also recorded.

Using the information entered into the database, each research article was categorized as either quantitative, qualitative, or mixed-methods. This categorization was based upon the coding of each articles research method section. Codes such as interviews, focus groups, content analysis, open-ended questionnaires and surveys, journals, and observations signified qualitative data collection and analysis (Bogdan & Biklen, 2007; Denzin & Lincoln, 2013; Clifford, Cope, Gillespie & French, 2016). Whereas codes such as pre-and post-test, experiments, evaluations, Likert scales, validity assessment, t-tests, Pearson's coorelation, ANOVA, and close-ended questionnaire and surveys were coded for quantitative data collection and analysis (Diggle & Chetwynd, 2011; Cumming, 2012; Clifford, Cope, Gillespie & French,

2016). Those articles that included both were coded as mixed methods. As noted above questionnaires and surveys can be considered either a quantitative or qualitative data collection method, based upon whether it was close-ended or open-ended. Many times researchers did not explicatedly state whether it was close-ended or open-ended. This leads to the importance of looking at how the data was analyzed in order to differentiate between a quantitative, qualitative, or mixed method research design. Therefore, close attention was paid to how the data was collected and how it was analyzed to ensure the correct categorization of the articles.

Each member of the research team analyzed the database and coded the articles. The research team crosschecked the coding results with one another to ensure each article was appropriately categorized. In-depth discussions took place to resolve any inconsistencies. Out of the 191 research articles reviewed, 55 articles were identified as quantitative, 65 were qualitative, and 71 coded as mixed methods.

## Results

### Quantitative Methods Used in Geography Education Research

We analyzed 55 articles identified as quantitative research studies according to the research topics, statistical and other quantitative techniques used, and strategies used to report the study results. Over half of studies that adopted quantitative approaches (34 out of 55) investigated effect of an educational intervention or compared effectiveness between different teaching strategies. Twelve (out of 55) studies investigated students' and teachers' knowledge and perceptions about various tools and pedagogical strategies in geography, such as Geographic Information Systems (GIS), web-based learning, and fieldwork.

Forty-nine studies applied statistical analyses, and popularly used techniques include *t*-test and analysis of variance (ANOVA) to compare means and correlation coefficients to determine correlations among variables of interest. In six articles about developing assessment tools, Cronbach's alpha was used to estimate the reliability and validity of the assessments. Table 1 presents frequently used quantitative methods in geography education and their main research objectives.

Table 1  
*Frequently used quantitative methods by research objectives*

Methods used	Objective of Analysis	Examples
<b>t-test and ANOVA</b>	Comparing Variables	Evaluating map overlay skills among grade levels. (Battersby, Golledge, & Marsh, 2006)
<b>Factor Analysis, Cronbach's alpha, t-test, &amp;</b>	Developing and Validating Assessments	Developing spatial thinking ability test. (Lee & Bednarz, 2012)



<b>ANOVA</b>		
<b>Factor Analysis, t-test, &amp; ANOVA</b>	Examining Perceptions	Surveying constraints to GIS usage. (Höhnle, Schubert, & Uphues, 2013)
<b>Chi-square test</b>	Others	Investigating the location and spatiality of questions in geography textbooks. (Jo & Bednarz, 2011)

For the 55 studies reviewed, p-value was almost the only indicator used to determine significance of the results. Only eight articles reported effect, and there were four studies reporting a confidence interval with the results.

### **Qualitative Methods Used in Geography Education Research**

A total of 65 articles that applied a qualitative research design was reviewed. Thirty-seven articles used interviews as the main data collection method, 12 articles used observation, and 40 articles used document analysis. Forty-five out of 65 articles used only one of the qualitative data collection methods, and the other 20 used more than one. All studies that used direct observation also used one or both of the other methods. Table 2 presents frequently used qualitative methods in geography education and their main research objectives.

Table 2

*Frequently used qualitative methods by research objectives*

<b>Methods used</b>	<b>Objective of Analysis</b>	<b>Examples</b>
<b>Interviews</b>	Gain an Individuals' Perception	Internet-based GIS in an inductive learning environment: A case study of ninth-grade geography students. (Milson & Earle, 2008)
<b>Observation</b>	Gain an Understanding of the Environment and the Interaction Between Participant and Observer	Environmental Learning Using a Problem-Based Approach in the Field: A Case Study of a Hong Kong School. (Kwan, 2008)
<b>Document analysis</b>	Examining the Content of Written/Historical/Archival Artifacts	Integrating geospatial technologies in an energy unit. (Kulo & Bodzin, 2011)

An example of using interviews is Milson and Earle (2008), who used a case-study research design to understand how to incorporate Internet-based GIS (IGIS) into a ninth-grade geography lesson on Africa, with the goal to understand the “implications of integrating IGIS into secondary geography classrooms and the potential for this

application [IGIS] to support inductive learning models of geography education” (p.227). The researchers used both classroom observations and focus-group interviews with students to better understand how students responded to IGIS. The interviews consisted of 48 students in 14 focus groups that were split into “above average,” “average,” and “below average” academic ability groups by the teacher. The interviews were semi-structured, allowing for descriptive and evaluative questions to be asked, along with follow-up questions for clarification on previous questions.

Forty articles used document analysis of written documents as at least one of the research methods. Kulo and Bodzin (2011) used all three major qualitative research methods, but their use of written documents and document analysis is exemplary. The study focused on integrating geospatial technologies into an energy unit for 110 eighth graders. The researchers used content analysis of written documents as the primary research method, but these were supplemented with observations by the researchers, interviews and debriefing sessions with the teacher after each lesson, written student artifacts and reactions to instructional materials, assessment responses that were embedded in the curriculum, and student journal entries. From these materials it was found that students were able to improve their knowledge and understanding of energy sources, along with their spatial thinking skills, through the implementation of the lesson using geospatial technologies.

Observation research was used by twelve articles. It was difficult to find an exemplary example of how observation can be used as a research method, as the articles that used this method did not clearly state how observation played into the findings of the study. In many instances, observations were written down and then analyzed as a written document. This was also the only research method that was not used alone for any of the studies. Despite the lack of replicability and research consistency across studies, there are exemplary models of qualitative research among the study articles for each method.

Research themes and content varied greatly from article to article. Articles that used one or more qualitative methods covered content such as GIS (e.g., Kulo and Bodzin 2011); fieldwork (e.g., Dummer, Cook, Parker, Barrett, & Hull, 2008); environmental learning (e.g., Ketlhoilwe, 2013); student conceptions of geography environmental learning (e.g., Bent, Bekx, & Brok, 2014); problem based learning (e.g., Kwan, 2008); and textbooks (e.g., Yang, 2013) in addition to many more.

### **Mixed Methods Used in Geography Education Research**

Among the 71 mixed methods articles, 26 used the explanatory research design. This result is not surprising as many researchers are most comfortable with the collection, analysis, and reporting of quantitative data. Quantitative methods are also the most desired and accepted for journal publication. Convergent and embedded designs accounted for 14 articles each, exploratory design was used in nine articles, multiphase design was used in seven articles, and transformative was used only once. A review of the geography education research provided a variety of ways to carry out qualitative and quantitative data collection. Quantitative methods included close-ended questionnaires, surveys, and pre-and post-tests. Qualitative data included interviews, focus groups,

open-ended questionnaires, and observations. There were articles that collected data qualitatively, but analyzed it quantitatively, and vice versa, simply showing the vast ways to conduct research.

An explanatory mixed methods design was applied by Wang and Chen (2013), where the researchers used a questionnaire and personal interviews to investigate Taiwanese teacher perceptions of GIS teaching, the popular pedagogies used by GIS teachers, the constraints that hinder the implementation of GIS teaching, and the distinguishing characteristics of GIS education in Taiwan. They explicitly state in their article that the personal interviews were conducted to supplement the results of the questionnaire and to obtain further information, identifying the key components of an explanatory design. The questionnaire included six categories, which were analyzed using Kolmogorov-Smirnov test, Shapiro-Wilk test, and Wilcoxon rank-sum test.

An example of a convergent mixed methods design is DiBiase and Kidwai's (2010) study. The research questions they posed were (1) why do older students seem to thrive better in this introductory course in geographic information, science, and technology, even though younger students are allegedly more accustomed to computing and information technologies and (2) what differences in student behavior, course design, and instructor roles should faculty members and administrators anticipate in relation to the ages of the students they plan to engage online? In order to answer these questions, they performed a quasi-experimental study and employed a mixed methods research design including quantitative and qualitative data. The experiment compared students from an undergraduate course (GEOG 121) and those from a continuing adult professionals course (GEOG 482). The data was collected and analyzed in several ways including records of student activity within the learning management system, student emails and discussion board postings, activity diaries kept by the lead author, surveys of student attitudes, and semi-structured telephone interviews with select undergraduate students. The quantitative and qualitative data was collected simultaneously throughout the course, and it was analyzed together to understand and explain the differences in performance and attitudes of younger and older adult learners.

An embedded mixed methods design can be found in Huang's (2011) article. Huang carried out an experimental design by developing two websites providing a different learning environment, one structured and one exploratory, which was used by two groups of students. As the students explored the web sites, the screens were videotaped to analyze students' Web-browsing behavior. Other quantitative and qualitative data was collected in the form of a geography achievement test on the content of the web sites, a student worksheet to be answered during the browsing of the web sites, and interviews and observations. The quantitative data were analyzed by using t-tests, and the interviews and observations helped the researcher understand students' cognitive model. The qualitative data was collected and analyzed to get a better understanding of the student actions. The qualitative data embedded in the primary quantitative research design provided a deeper understanding.

Solem and Foote's (2006) article is an example of exploratory mixed methods design, exploring the experiences of early career geography faculty by using focus

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group interviews as a source of qualitative data, which helped formulate hypothesis for a more detailed study using a written questionnaire. The interviews, analyzed using HyperRESEARCH software, identified fifteen distinct career issues and perceived effective strategies for coping with these issues. In order to verify the significance of the career issues raised in the focus groups and their relationship with social and professional characteristics, a written survey was administered to a sample of faculty to collect quantitative data. Factor analysis, Principal Components Analysis (PCA) with Varimax rotation, Cronbach's alpha, Mann-Whitney U test, and the Kruskal Wallis test were all ways the quantitative data were analyzed.

An article by Boehm, Brysch, Mohan, & Backler (2012) provides an example of a multiphase mixed methods design. An online professional development series targeted for pre- and in-service grade 6-9 geography, science, and environmental science teachers was proposed as a new way to provide professional development for geography teachers. In order to determine the receptiveness of an online program compared to face-to-face, there were multiple phases of data collection. During this first phase of preliminary research, four groups were surveyed, each with a different set of open and close ended questions, to get an idea of the potential value and use of the program. The second phase involved an experiment that compared the online professional development program to traditional face-to-face professional development with two groups of teachers. After each group experience both styles of professional development, they were asked to complete a Likert-scale survey to compare the two styles, which was analyzed using a chi-square goodness-of-fit test.

Lastly, the article by Brinegar (2001) shows an example of a transformative mixed methods design. The paper is written from a feminist perspective, and the overall purpose is to report on women's progress in the discipline of geography by using a variety of data sources to analyze. The data sources used included figures from the National Center for Education Statistics and the National Science Foundation, journals and publications produced by the Association of American Geographers, and a qualitative survey from US doctorate-granted geography departments. Female representation both in faculty and students was determined by the percentages and number graduated. The percentages of research articles authored by women was also documented and analyzed.

## **Discussion**

Out of the 191 research articles reviewed, 55 articles were identified as quantitative, 65 qualitative, and 71 were identified as mixed methods studies. As research design is closely related to specific types of inquiry and research questions, the variety of research designs found can be considered a reflection of the numerous inquiries and research questions investigated in geography education. Despite the relatively fewer numbers of quantitative studies it does not mean that geography education researchers were less concerned with research questions that can be investigated through quantitative research techniques. Instead, it could be attributed to the publishing tendency of quantitative results. According to Cummings (2012), researchers whom fail to get a statistical significant finding are hesitant to submit their work for publication,

while those who have statistical significance are more likely to be accepted and published. This is also called the “file drawer problem” as suggested by Rosenthal (1979), where publication bias occurs in journals by depicting only 5% of studies conducted while the other 95% are filed away due to nonsignificant results. In contrast, research that adopted qualitative or mixed methods research designs is relatively free from the restraint of statistical significance.

This study found that the most popular statistical analysis methods in geography education are *t*-test and the analysis of variance (ANOVA) as most of the studies involve comparing two or more means. For reporting the results of analysis, *p*-value was almost the only indicator used to determine significance of the findings. Few studies reported confidence intervals or effect sizes, and no single study reported both together. According to the American Psychological Association (2009), reporting both confidence intervals and effect sizes has been highly recommended in reporting quantitative research in education. Scholars also suggest that effect sizes can be more useful when reported with confidence intervals (Preacher & Kelly, 2011). In addition, according to the recommendations by American Psychological Association for reporting educational research, all basic information about the data, such as descriptive statistics (e.g., mean, standard deviation, and original units) must be reported at all times because providing such information helps replicating the study and eventually accumulating knowledge. However, reporting confidence intervals and effect sizes is still uncommon in geography education research.

There is little consistency in the types of studies undertaken using qualitative methods. While the methods used for this study were placed into three main categories, the sub-categories varied widely. The 65 articles that were categorized as qualitative adopted a total of 26 slightly different methods to collect data. Among the studies reviewed, there was not a single pair of articles of which the results are comparable. Each study deals with perceptions, opinions, understandings, and other not-easily measured characteristics of a specific group of individuals in a unique context.

As mentioned earlier, data can be collected and analyzed in various combinations of quantitative and qualitative methods to be considered mixed methods. This being said, there is not one correct way to perform mixed methods research. Each article identified the data collected, a mandatory section of a published research article, but very few of the articles discussed the data collection methods and analysis exclusively or extensively. This made it difficult to decipher which mixed methods design was used based upon Creswell and Plano Clark’s design definitions (2007, 2011), leaving it up to the judgement of the research team.

The purpose of this review was to examine research methods, techniques, and reporting strategies that have been commonly used in geography education and provide a list of example research studies representing those methods. This article does not discuss in detail all of the various ways data is collected and analyzed but we do hope it provides a starting point on what type of research design and methodological approach you will want to conduct with some examples of how it was used in context. Some researchers may want to explore large statistical datasets, such as the National

Assessment of Educational Progress (NAEP) results, while others want a more personal experience concentrated on interviews and focus groups to understand a problem. Whichever type of researcher you may be it is important to know where to begin. This paper will serve geography education researchers, especially for early career scholars and graduate students, as a reliable reference to reviewing and comparing various research methods used in the field and deciding appropriate ones for their own research endeavor.

### **Conclusions and Recommendations**

*A Road Map for 21<sup>st</sup> Century Geography Education: Geography Education Research Committee* called for an increase in replicable studies that will increase the knowledge and quality of research in geography education. This is another call to the geography education research community to increase the number of sound research protocols and designs in the discipline (Downs 1994, Stoltman, 1997). In order to build a base for future research that is grounded on the previous research design and findings, a clear and detailed report of the methodologies and the results is critical. The views expressed in this article are based upon the authors and we do not expect everyone to agree. We acknowledge that our findings may be different than the original intentions of the authors cited and studied. However, our conclusions express our recommendation for an immediate call of action to publish stronger research articles in geography that build upon existing research literature and studies, producing more longitudinal and transformative works.

We looked at quantitative studies and saw the majority of researchers use NHST, and we discuss the advantages of including effect sizes and confidence intervals into the results to provide a more accurate picture of the research. It is not the purpose of this article to argue that we should follow this new method because other disciplines have already accepted it. Rather, we suggest that reporting practical significance of the study findings contribute to building a more comprehensive knowledge about the phenomena investigated in geography education research studies.

Based on the qualitative studies reviewed, we conclude that geography education researchers can benefit from more coordinated research efforts across topic. The primary purpose of these studies was to better understand how various teaching styles, project types, learning environments, and other factors influence how geography is taught and learned across age groups, educational levels, and cultural backgrounds. It would be worthwhile to investigate the same research questions using the same methodologies but with different participants in different geographical and educational settings. This can be accomplished when studies report the methodologies and research procedures in greater detail.

A mixed methods methodology is a valuable research design in the field of geography education. Collecting and analyzing both quantitative and qualitative data proves to be beneficial in improving various aspects of research. Whether it is about GIS, professional development, or the teaching and learning of geography, mixed methods can help answer the research questions in a unique way different from a lone quantitative or qualitative research design. We suggest that when submitting a mixed

methods study for publication, the article should address all the necessary components of a mixed methods design as outline by Creswell and Plano Clark (2007, 2011). These components include: data collection methods; data analysis methods; the timing of when the methods were employed, such as qualitative then quantitative, vice versa, or at the same time; and, the purpose of conducting mixed methods. Following this reporting style is a good habit no matter what methodology and design is used.

We strongly encourage future geography education researchers to look at how previous research in geography education has been done and take this article into consideration when developing their own research designs. Research can be intimidating, but there are plenty of exemplar studies out there that we can refer to guiding our research questions. The geography education community must find a way to move forward effectively so that in ten years we are not repeating ourselves about the need for more data and research.

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