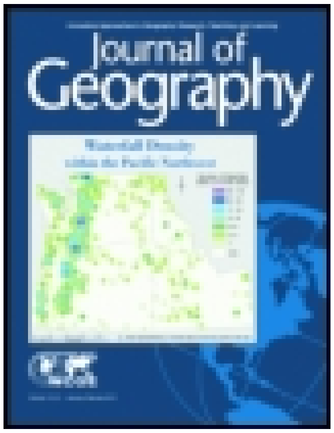

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Spatial Thinking Ability Assessment in Rwandan Secondary Schools: Baseline Results

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Abstract

This article discusses use and modification of Lee and Bednarz's (2012) Spatial Thinking Ability Test (STAT) as a spatial thinking assessment device in Rwandan secondary schools. After piloting and modifying the STAT, 222 students total from our rural and urban test schools and one control school were tested. Statistical analysis revealed that urban test school students outperformed rural test school students and that males outperformed females. Also observed were significant differences in performance for particular STAT question categories that can be used to inform strategies for spatial thinking curricular development and further modifications to the STAT in other contexts.

Key Words: *assessment, secondary education, spatial knowledge*

Brian Tomaszewski is an assistant professor in the Department of Information Sciences and Technologies, Rochester Institute of Technology, Rochester, New York, USA. His research interest areas are geographic information science and technology, spatial thinking, geographic visualization, and disaster management.

Anthony Vodacek is an associate professor in the Chester F. Carlson Center for Imaging Science, Rochester Institute of Technology, Rochester, New York, USA. His research interests are in the areas of remote sensing phenomenology, image processing algorithms, and dynamic data-driven models of processes in natural and built environments.

Robert Parody is an associate professor in the Center for Quality and Applied Statistics, Rochester Institute of Technology, Rochester, New York, USA. His main research interests are in experimental design, model building, continuous improvement and statistics in education.

Nicholas Holt is a physics and English major at Furman University, Greenville, South Carolina, USA. His contributions to this article came through experiences gained via the Rochester Institute of Technology National Science Foundation Research Experience for Undergraduates (NSF-REU) program number PHY-1062874.

Introduction

Spatial thinking uses the properties of space such as scale, distance, and direction to structure and solve problems ranging from simple navigation to complex scientific inquiry. A desire to incorporate spatial thinking concepts into secondary (or K–12) and postsecondary (undergraduate college) teaching has grown in the past decade (National Research Council 2006b). This advocacy is bolstered when there are effective tools for spatial thinking ability assessment. In this article, we present initial results of using and modifying Lee and Bednarz's (2012) Spatial Thinking Ability Test (or STAT) as a spatial thinking ability baseline-assessment device. Our use and modification of the STAT is within the context of a broader two-year research project investigating spatial thinking skill development in Rwandan secondary schools. In this article, we provide the background for our use and modification of the STAT within the Rwandan secondary school context, the statistical results of using the modified STAT as a baseline exam, and suggestions for how to further revise curriculum and the STAT based on our baseline results.

The Rwanda Educational Context and the Innovation for Education Program

Rwanda has made incredible social, economic, and civil progress since the tragic and horrific events of the 1994 genocide. In regard to educational progress, the Rwandan Ministry of Education (MINEDUC) has developed the Education Sector Strategic Plan (ESSP) 2010–2015 to define pathways for overall educational sector improvement by providing "Access to quality, equitable and effective education for all Rwandans" (MINEDUC 2010, 1). Support for educational development is further articulated in the Government of Rwanda Vision 2020 plan to transform Rwanda into a knowledge-based society (Republic of Rwanda n.d.). The ESSP is strongly aligned with Rwanda's broader national Economic Development and Poverty Reduction Strategy (EDPRS) that contains high level education objectives (ESSP objectives), which are: "1—Access to education for all, 2—Quality education at all levels, 3—Equity in education at all levels, 4—Effective and efficient education system, 5—Science and technology and ICT (Information Communication Technology) in education, and 6—Promotion of positive values, critical thinking, Rwandan culture, peace, unity and reconciliation" (MINEDUC 2010, 1).

The Innovation for Education (IfE) Program, which is funded by the United Kingdom (UK) Department for International Development (DFID) and implemented in partnership with the Rwandan Ministry of Education is specifically aligned with the ESSP objectives where the IfE program is "an opportunity to test new ideas to improve the quality of education in Rwanda" (MINEDUC 2012, 1). Within this policy context we identified a curriculum gap where spatial thinking skills are significantly underrepresented in Rwandan secondary education. This gap exists despite great efforts made at introducing information communication technologies (ICTs) into Rwandan secondary schools (e.g., geographic information systems) and much work remains to relate the use of such tools to spatial thinking skills and spatially oriented-problem solving (Environmental Systems Research Institute—Rwanda 2013).

In response to the IfE program, we created a project designed to introduce spatial thinking into the Rwandan curriculum and to assess improved student

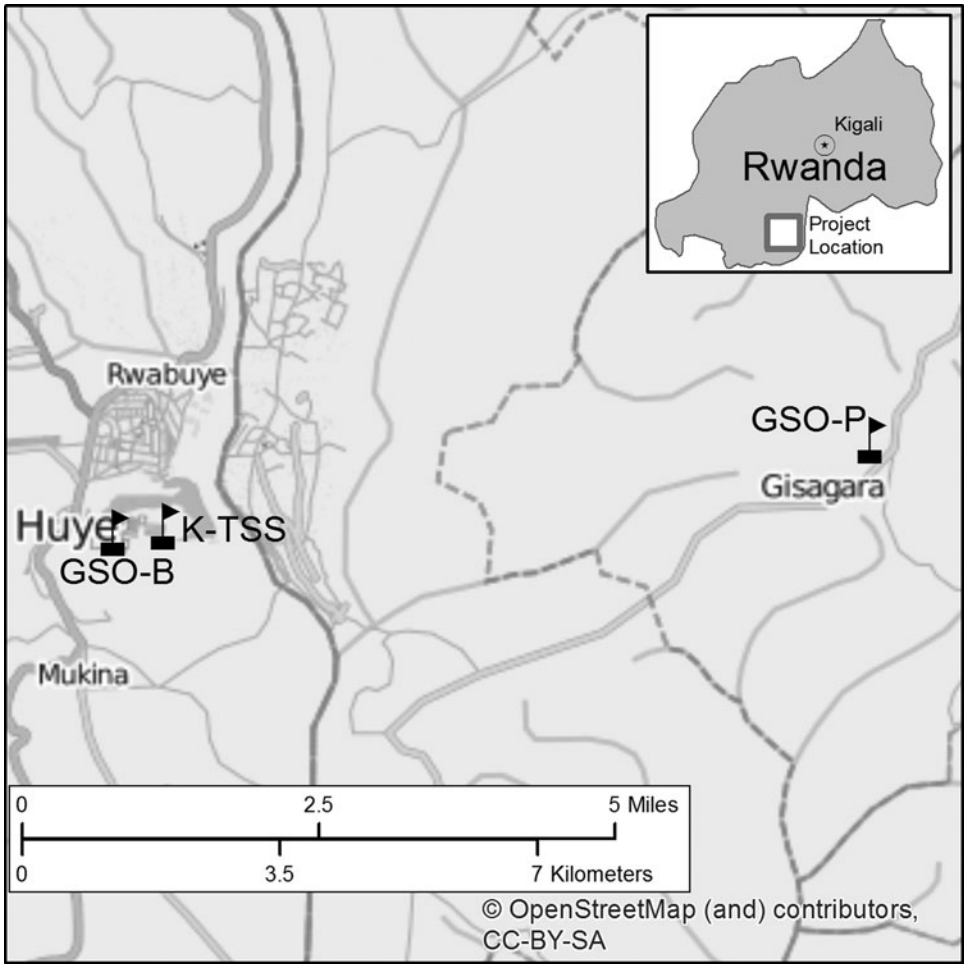

Figure 1. Map showing location of the three schools.

outcomes arising from the new curriculum. The Rochester Institute of Technology (RIT) is the project lead with partners from the Centre for Geographic Information Systems and Remote Sensing (CGIS) at the University of Rwanda Huye campus and the Rwanda Environmental Conservation Organization (RECOR), a Rwandan environmental NGO (nongovernmental organization). The RIT team consists of a geographic information scientist and remote sensing scientist versed in relevant spatial thinking theory and assessment techniques, geospatial technology development, and environmental mapping and is taking the lead in modifying the STAT. CGIS is responsible for geospatial technology teacher training at the participating schools in collaboration with RECOR. RECOR conducts research on natural resource management topics such as biodiversity conservation and water availability and has extensive experience with environmental education in Rwandan schools. CGIS and RECOR are both working closely with RIT to facilitate monitoring and evaluation (M&E) activities such as modifying and administering the Spatial Thinking Ability Test (STAT).

Project Design, Monitoring, and Evaluation

Three schools are participating in the project (Fig. 1). Two are test schools receiving intervention from our IfE project in terms of teacher training, geospatial technology curriculum, and geospatial technology equipment donations. The other school agreed to serve as a control school to help determine if our IfE project interventions, as measured by the STAT, are in fact statistically significant.

Groupe Scolaire Officiel de Butare (GSO-B) is a test school located in an urban area of the Huye sector, Butare district of Rwanda (Indatwa N'inkesha School 2010). GSO-B is one of the oldest secondary schools in Rwanda, having been established by the Brothers of Charity in 1929 to educate Rwandans for Belgian colonial administration support. Many of the students who attend GSO-B are from financially well-off families from Kigali (Rwanda's capital city) and have had access to better quality education before attending GSO-B.

Groupe Scolaire Officiel St. Philippe Neri (GSO-P) is a test school located in the rural area of the Ndora sector, Gisagara district of Rwanda. GSO-P draws a variety of students from across Rwanda and varying socioeconomic backgrounds.

Ecole agricole et veterinaire de Kabutare (K-TSS) is the control school located in the urban area of Huye sector, Butare district of Rwanda. K-TSS focuses on vocational training in the areas of agriculture, forestry, and veterinary science.

An important component of the IfE project is project outcome monitoring and evaluation (M&E). DFID was particularly interested in understanding how the process of educational innovation (developing spatial thinking skills through geospatial technologies) could be measured and evaluated for potential scale-up, thus our use of the STAT as an assessment tool. Although beyond the scope of this article to report every aspect of our project's M&E, we do report on select aspects of our project outcome evaluation strategy as it pertains to STAT use and modification.

To begin, we gave a revised STAT to a small set of students as a pilot study to identify any potential STAT usability issues. We then further modified the STAT based on the pilot results and gave the final revised STAT to a larger set of students to establish baseline student performance prior to the introduction of any of our spatial thinking curriculum and supporting technology at the schools. Our experiences with the STAT pilot, STAT revisions, and baseline study are this article's focus.

As part of this baseline study, the characteristics of our schools (rural and urban) and the broader project context to promote quality, equitable, and effective education led us to two working hypotheses we wished to investigate via the STAT. More specifically, we hypothesized that:

1. The urban school (GBO-B) will perform better on the STAT as compared to the rural school (GSO-P).
2. Females at both test schools will not perform as well as males.

We also wished to explore general comparisons between the schools in terms of interactions between the variables of gender, school grade (i.e., age), and STAT question group and their interactions. These variables of gender, age, and spatial thinking ability are commonly used for evaluating group differences (National Research Council 2006a).

The Spatial Thinking Ability Test Pilot

Spatial Thinking Ability Assessment

Long the purview of geographers, engineers, and other scientists interested in spatially oriented reasoning and problem solving, spatial thinking has only recently gained attention and advocacy for formal incorporation into educational curricula—most notably through the 2006 National Research Council (NRC) report *Learning to Think Spatially: GIS as a Support System in the K–12 Curriculum* (National Research Council 2006b, 5). The NRC report provided a working definition of spatial thinking as "a constructive amalgam of three elements: concepts of space, tools of representation, and processes of reasoning." This report has had a profound influence on geographic and other educational practice by defining what spatial thinking is, how spatial thinking ability is acquired and operationalized in many forms, and how teaching spatial thinking can be supported through technology. A significant observation drawn from the NRC report was that no standardized spatial thinking ability measures were suggested, thus making it challenging to assess changes in spatial thinking ability as the result of educational intervention. Drawing upon the NRC report and other past spatial thinking research, Lee and Bednarz (2012) presented the results of developing and assessing a standardized Spatial Thinking Ability Test (STAT). Using past work to develop test question categories (Gersmehl and Gersmehl 2007; Golledge, Marsh, and Battersby 2008; Janelle and Goodchild 2009), the STAT was designed to test for the existence of eight spatial thinking ability components using sixteen test questions. The following list outlines the eight spatial thinking ability components (indicated with roman numerals) with the corresponding STAT questions of the component indicated in parenthesis:

i. Comprehending orientation and direction (questions 1 and 2).
ii. Comparing map information to graphic information (question 3).
iii. Choosing the best location based on several spatial factors (question 4).
iv. Imagining a slope profile based on a topographic map (question 5).
v. Correlating spatially distributed phenomena (questions 6 and 7).
vi. Mentally visualizing 3-D images based on 2-D information (question 8).
vii. Overlaying and dissolving maps (questions 9, 10, 11, and 12).
viii. Comprehending geographic features represented as point, line, or polygon (questions 13, 14, 15, and 16) (Lee and Bednarz 2012, 18).

The authors of this article deemed the eight spatial thinking components and the STAT test itself to be the best example to date of a rigorously evaluated, conceptually robust, and thoroughly validated spatial thinking assessment device. Additionally, it is important to note that although Lee and Bednarz (2012) ultimately found that the eight components of spatial thinking did not exist as independent, discrete categories of spatial thinking ability and that spatial thinking is a combination of these abilities, the components themselves were deemed very useful to our research for two reasons. First, they were useful for comparing specific differences in STAT scores between our project schools. Second, they were useful for identifying specific curricular intervention areas. For example, and as discussed later in this article, low scores in category viii questions (comprehending geographic features represented as point, line, or polygon), could indicate the need for either further refinement of STAT question design or technical geographic information systems (GIS) training with vector datasets as opposed to general map-reading ability that could be a curricular focus based on low scores in category I (comprehending orientation and direction).

Thus, the STAT was chosen as the spatial thinking measurement device as the purpose of our overall research program is to develop and assess spatial thinking ability and not to develop new spatial thinking ability assessment devices or measure spatial thinking expertise (Huynh and Sharpe 2013).

STAT Pilot Results, Usability Study, and Modifications

We modified the STAT before conducting our pilot test as the STAT was developed for and tested with secondary and college students in United States, and our CGIS and RECOR partners recommended STAT changes to fit the Rwandan cultural and educational context. None of the changes modified the spatial thinking ability component classification of a given question. Rather, changes mostly focused on cultural modifications (i.e., using metric units, maps of Africa instead of the United States, eliminating context specific to a developed country) and question interface design modifications. We also modified the original STAT for printing in black and white due to printing resource limitations in Rwanda.

In June 2013 we administered our STAT pilot. To minimize bias, the STAT was administered at our two test schools (GSO-P and GSO-B) and given equally to male and female students. Our total pilot student sample size was twenty and none of these students took part in the baseline study. We also administered a STAT usability survey after the students took the exam to identify any issues the students had with the STAT that could be acted upon before administering the final baseline test. Usability studies are a very common technique used for evaluating how well a person can accomplish tasks using an interface and we followed well-established guidelines for developing our short usability study form, such as Likert-scale questions and nonleading, open-ended questions (Dumas and Redish 1999; Nielsen 2005). The purpose of this study was to solicit student feedback about any usability issues students had with the STAT due to the exam's origins in a U.S. education context and thus provide justification for making any potential modifications to the STAT baseline version.

Raw pilot exam and usability survey data were assessed with basic summary statistics (mean scores, percentage of answers questions correctly). For open-ended, write-in questions on the usability survey, qualitative analysis in terms of trends and patterns found in the responses was conducted. Given the small sample size, this analysis was done manually.

The average number of questions answered correctly for all genders and both schools on the pilot STAT was 5.15 out of sixteen questions or an average percent score of 31.14 percent. By gender, no significant differences were seen, with females averaging 29.86 percent and males averaging 32.91 percent. When comparing gender-neutral average scores between schools, clear distinctions were found. GSO-B students averaged 34.7 percent correct compared to 27.5 percent correct by GSO-P students. We attribute this clear difference to the fact that GSO-B students have better science and math backgrounds than GSO-P students and may have developed better spatial thinking ability due to subjects such as geometry.

The usability study used five-point Likert-scale questions (ranging from 1 = *strongly disagree* to 5 = *strongly agree* and a *N/A—don't know* option) with the following results: (1) *I understood what the STAT questions were asking of me (3.7/5)*, (2) *I think other students will be able to understand the STAT (3.3/5)*, (3) *The STAT questions were generally difficult to answer (3.1/5)*, and (4) *With more learning about mapping and spatial concepts, I think I could do better on the STAT (4.6/5)*. Despite overall low STAT pilot test scores, most students reported they found the STAT easy to use; of particular interest is that almost all students strongly agreed that they could do better on the STAT with more spatially oriented education (question 4).

The STAT pilot usability short response questions were (1) *Describe any specific problems you had using the STAT,* (2) *Describe any specific STAT questions you didn't understand and why you didn't understand them*, and (3) *Provide any additional feedback about the STAT pilot test*. These questions provided qualitative evidence for problems that tended towards English language issues and a lack of geography skills as evidenced in quotes such as "Not used to geospatial questions or geography" and "It is difficult to understand what the questions are asking." Based on the usability survey, we revised the STAT to have clearer language and more visual cues to help students answer the questions. For example, on a question where a student was to circle a final site on a map after reviewing a series of four maps, some students wrote their final response outside that map or simply placed a check mark near one of the maps as opposed to circling the final site location as instructed. Figures 2 and 3 represent an example of one STAT question modification centered on layout redesign and rewording.

As shown in Figures 2 and 3, the question content remained the same. However, the question has been redesigned to have a top to bottom flow along with large arrows to direct the test taker's focus and attention. The following is a list of all changes made after the STAT pilot test[1]:

- Increased margins to avoid printing problems (i.e., questions spanning two pages);
- Revised opening pages of the STAT by providing clear direction to what both the student and the test administrator should do;
- Modified question 4 so the criteria are more direct, using arrows as visual prompts, circling answers instead of making check marks;
- Question 5, 6, 8—slight modification to question/answer prompt layout;
- Question 7—added a legend to help make the maps easier to interpret;
- Questions 9 to 16—slight modification to question/answer prompt layout; additional answering guidance text added.

The Rwanda STAT Baseline—Results

Overview

The STAT baseline was administered at all three project schools to a total of 222 students, with roughly one-third from the control school (K-TSS) and one-third each from the two target schools (GSO-B and GSO-P). At each school, students were assembled in a large room and in configurations of two to three students per desk; note, too, the lack of chalkboards, charts, maps, or other teaching support devices (Fig. 4). The baseline test score data was analyzed for statistical significance in relation to school, gender, grade level, and exam question group in terms of

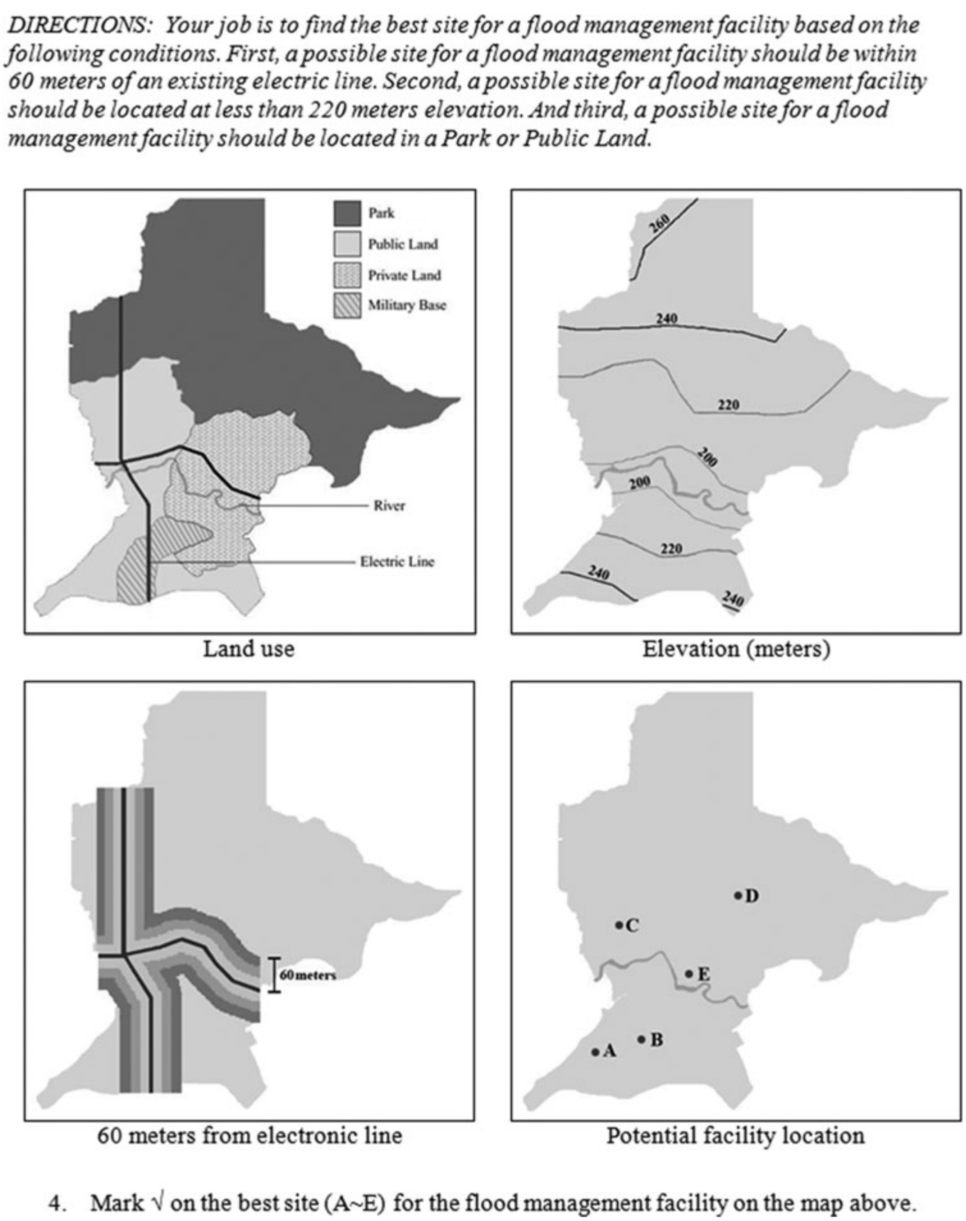

Figure 2. Modifying the STAT based on feedback from the pilot STAT. This figure shows question 4 from the STAT pilot exam. (STAT Images © 2006 Association of American Geographers (AAG); Dr. Jongwon Lee, STAT author.)

the question's spatial thinking component based on Lee and Bednarz (2012).

Results

There were a total of seventy-four students from GSO-B, seventy-three from GSO-P, and seventy-five from K-TSS. The gender breakdown was eighty-eight females and 134 males. Although we planned for equal male and female numbers, due to unforeseen circumstances in overall student composition we were unable to maintain gender equity. There were 157 students in senior grade four and sixty-five in senior grade five. We specifically targeted students in these grades so that they will be available for future follow-up testing. The overall average percent score on the exam was 39 percent. Students scored highest on questions 1 (63.5%) and 6 (62.6%). The lowest score was on question 8 (16.7%).

We also analyzed the data across all grades, genders, and schools by each question group according to the spatial thinking component represented by the question as defined in Lee and Bednarz (2012). The highest score came from group I (60.8%) and the lowest score came from group VI (16.7%). Group I includes questions 1 and 2. These two questions yielded the highest and third-highest scores among the individual questions. Group VI only included question 8. To assess the significance of score results, we performed a logistic regression utilizing a type I error rate of 5 percent. Table 1 lists the results of a logistic regression taking into account subject variability.

The results demonstrate that the main effects for school, gender, question group, and the interaction for school by question group are each significant. The logistic regression was repeated for a reduced model that included only the significant sources. Within the reduced model, the same effects remained significant. For example, in terms of exam score by gender, the observed scores for males and females respectively were 40.2 percent and 37.3 percent. In terms of exam score by school, students at GSO-B did the best overall within an average score of 57 percent, GSO-P did second best with an average score of 40 percent, and the K-TSS students scored the lowest at around 20 percent. Figure 5 illustrates exam scores by school and question group.

The observations illustrated in Table 1 and Figure 5 can be confirmed by statistical inference. Table 2 indicates which pairs of schools scored significantly different on the exam based on question group. A gray-shaded cell indicates there is a significant difference between the scores on the exam for that school pair for a given question group.

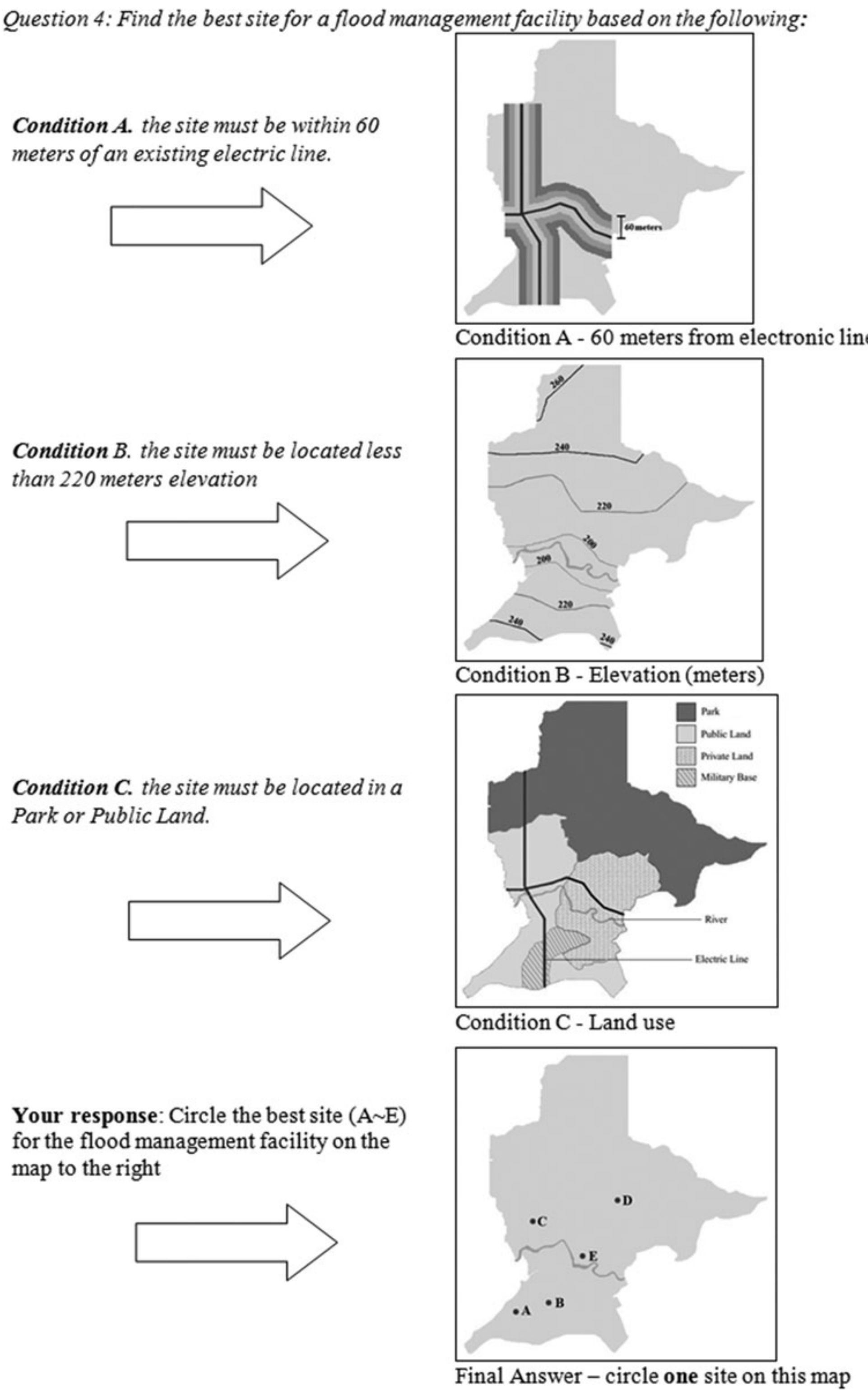

Figure 3. This figure shows the same question shown in Figure 2 but the design of the question modified for the use in the STAT baseline exam. (STAT Images © 2006 Association of American Geographers (AAG); Dr. Jongwon Lee, STAT author.)

Table 2 indicates that when comparing GSO-B and K-TSS, there are significant differences for all question groups except for group VI. For GSO-P and K-TSS, there are significant differences within groups I, IV, V, and VII. Finally, for GSO-B and GSO-P, there are significant differences within groups V, VII, and VII. Overall, it is of interest to note that groups V and VII yield significant differences for all pairs of schools and there are no significant differences for any pairs of schools for group VI.

Discussion

Comparing Pilot Exam Results to the Baseline Exam

The pilot exam average score was 31.14 percent. The baseline exam average score was 39 percent. Thus, changes made to the STAT after the pilot exam as discussed previously may have made a small contribution to improving the overall scores due to alleviating student question response issues. However, the (1) small difference in pilot and baseline scores and (2) overall low scores more likely indicate the general difficulty of the STAT despite modifications made. It is also worth noting that GSO-B clearly outperformed GSO-P on both the pilot and the baseline.

Baseline Exam Results Analysis

The baseline assessment has demonstrated a number of statistically significant measures against which we can determine whether further STAT modification coupled with curricular intervention produces significant spatial thinking skill improvement. We previously stated two hypotheses we were interested in and now discuss how our baseline STAT results address these hypotheses.

Our first hypothesis was that the urban school (GBO-B) would perform better on the STAT as

Figure 4. Rwandan secondary students taking the STAT baseline at Kabutare TSS, July 2013. (Photo by Brian Tomaszewski.)

compared to the rural school (GSO-P). In addition to overall higher average scores, we did find statistical significance that GSO-B outperformed GSO-P in terms of interaction between school and STAT question group (chi square: 56.78, p value: <0.0001). The overall average higher STAT scores we attribute to our previously stated intuition that GSO-B would perform better as GSO-B students have better educational backgrounds and opportunities than GSO-P students. For example, GSO-B has better teaching and learning resources than GSO-P such as a full library, well-trained teachers, and modern computing resources. Additionally, in Rwanda national examination scores determine student secondary school placement. Higher scoring students are placed in top secondary schools such as GSO-B. Although educational quality rankings of Rwandan secondary schools are not available, from personal conversations with our Rwandan colleagues, GSO-P is considered a middle-tier school in terms of overall education quality.

In terms of statistical differences between GSO-B and GSO-P and STAT question categories V (correlating spatially distributed phenomena), VII (overlaying and dissolving maps), and VIII (comprehending geographic features represented as point, line, or polygon), we attribute these interactions as due to the fact that many GSO-B students selected for the exam are math and calculus majors as opposed to GSO-P students majoring in math, chemistry, and biology. Thus, GSO-B students have better skills at numerical and graphical correlation associated with data (group V questions), Boolean logics (group VII questions), and geometric representation (group VIII questions).

STAT question group VI (mentally visualizing 3-D images based on 2-D information) was the only question group that GSO-B did not show statistical difference between both K-TSS and GSO-P. We attribute this fact to the students' geography and earth science training at both GSO-B and GSO-P, occurring two or three years prior to taking the STAT. Additionally, teachers at both schools have limited 3-D software technology awareness. For example, the students have never received instruction on using virtual globe technologies like Google Earth for learning about water drainage via 3-D slope profile representations (Butler 2006).

For GSO-P, scores were particularly low on STAT group type questions V (correlating spatially distributed phenomena), VII (overlaying and dissolving maps) and VIII (comprehending geographic features represented as point, line, or polygon). We attribute low scores in these three categories based on Rwandan school context and the nature of the Ordinary level geography curriculum students received two to three years prior to taking the STAT. For example, the Ordinary level geography curriculum makes no explicit mention on learning about correlations between spatial and nonspatial data such as rainfall level and vegetative cover (relevant to type V questions). The curriculum does have a learning outcome related to the use of statistical devices as reflected in this quote, "Use statistical data to construct

Table 1. Logistic regression results testing for significance of score variability sources.

Source	DF	Chi-square	p value
Grade	1	0.82	0.3654
School	2	44.83	**<.0001**
Gender	1	11.34	**0.0008**
Group	7	26.13	**0.0005**
Grade*School	1	2.89	0.0891
Gender*Grade	1	3.55	0.0595
Grade*Group	7	6.04	0.5354
Gender*School	2	0.74	0.6918
School*Group	14	48.14	**<.0001**
Gender*Group	7	2.68	0.9131

Note: p values in bold are significant.

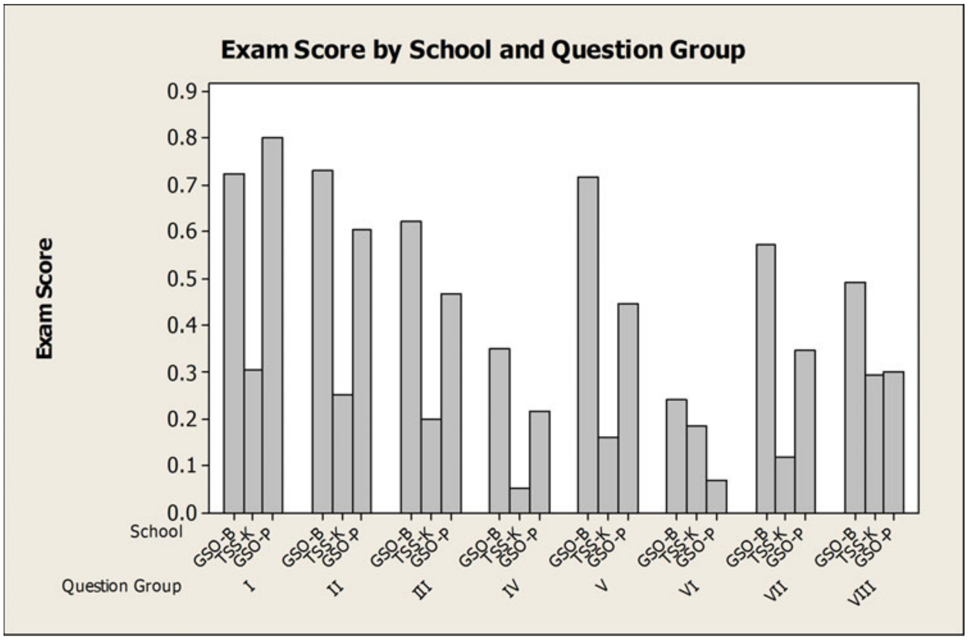

Figure 5. Score correct by question group and school. K-TSS scores are consistently lower than the other schools except for question group VI, where it scored higher than GSO-P.

a graph showing the temperature and rainfall of areas" (Ministry of Education National Curriculum Development Centre 2008, 14) but does not discuss combined geographic map/statistical chart use. The Ordinary level geography curriculum also makes no mention of understanding spatial interactions between different geographic variables (relevant to type VII questions). An example here would be overlaying separate map layers together to understand how wetlands spatially interact with animal habitats to define an environmentally sensitive area. The curriculum does have this learning outcomes, "Explain the relationship between vegetation and human activities" (17), however, the curriculum makes no mention of using map overlays or geoprocessing operations such as union, difference, and intersection found in industry standard GIS software as a means to explain human-environment relationships. Finally, for type VIII questions, the Ordinary level geography curriculum does have learning outcomes generally related to data digitization, capture, and transformation, "Identify physical and human aspects on a photograph" and "Draw a sketch to represent the Photograph" (57). However, these outcomes are more related to creating diagrams. They are not exactly the same as digitizing features from remotely sensed imagery into vector-based points, lines, and polygons as is done with GIS and per type VIII questions.

Our second hypothesis was that females at both test schools would not perform as well as males. We found statistical significance that males outperformed females averaged across all of the other variables (chi square: 11.17, p value: 0.0008). We are initially attributing this interaction due to broader, systemic educational access and quality for females in Rwanda deriving from entrenched social barriers and practices in Rwandan society (Huggins and Randell 2007). Factors that could also contribute to the gender difference, but that are outside the scope of this work, include developmental emergence, biology, and interactions between the two (National Research Council 2006a) and the structure of Rwandan households in terms of the relation of a child to a household head and access to free education in Rwanda (Nkurunziza, Broekhuis, and Hooimeijer 2012).

School and STAT Question Category Comparisons

In addition to insights from the two specific hypotheses tied to our broader project research goals, we found one unanticipated but statistically significant interaction between the schools and STAT question category. As previously stated, GSO-B and GSO-P outperformed K-TSS on the STAT in terms of overall average score. However, STAT question category scores between GSO-B and K-TSS and between GSO-P and K-TSS were all statistically significant except for group VI questions (mentally visualizing 3-D images based on 2-D information). The lack of statistical significance differences for the group VI question categories between K-TSS and the two other schools could be due to the fact that K-TSS's vocational focus on forestry and surveying has enabled K-TSS students to have better spatial thinking ability derived

Table 2. STAT question group (indicated as roman numerals) against the school pairs. A gray-shaded cell indicates a significant difference.

Group	GSO-B/K-TSS	GSO-P/K-TSS	GSO-B/GSO-P
VIII			
VII			
VI			
V			
IV			
III			
II			
I			

from tasks such as reading topographic maps and field mapping that are the subject of group VI questions.

Future Work

Based on our baseline examination results, our future work activity will focus on improving the overall STAT scores at our two test schools (GSO-B and GSO-P) and specifically addressing the statistical differences between STAT question categories found at each school to address specific spatial thinking knowledge gaps at the schools. For example, we are currently developing curriculum to incorporate free 3-D mapping technology and commercial GIS tools available through agreements between Esri-Rwanda and the government of Rwanda to address the low scores on the group V, VII, and VIII questions discussed previously. Due to lower female STAT scores, our hypothesis that females would not perform as well as males and the aforementioned Rwandan cultural issues surrounding girls, we are also planning to conduct learning activities focused specifically on girls such as mapping clean drinking water access (a task typically conducted by rural Rwandan women) to empower and inspire girls to be agents of change in communities and address gender-specific issues revealed from STAT result analysis.

Finally, to assess whether or not our STAT modifications and curricular interventions are improving the spatial thinking of the students at our two test schools (GSO-B and GSO-P), in the mid-project and end of project phases of this work we will have the same students at the same three schools take the STAT test again. To ensure reliability from our results across multiple administrations of the STAT, we are not planning to make any substantial new revisions to the STAT. We plan to publish comparisons of the baseline exam with these follow-up tests in the near future.

Summary and Conclusions

In this article, we have described our research focused on measuring spatial thinking skills of Rwandan secondary students. The main contribution of this article has been our experiences with using and modifying Lee and Bednarz's (2012) Spatial Thinking Ability Test (STAT) to support our project assessment activities in terms of measuring spatial thinking ability. We first described how we piloted the STAT in Rwanda and made STAT adjustments based on results and feedback from the pilot STAT to complete a baseline study. We then presented results of the STAT baseline and a variety of statistical measures to analyze specific hypotheses our project is interested in in terms of comparing rural and urban schools and gender differences. We examined STAT result data for any potential insights between the variables of gender, school, and STAT question category. The results of our analysis concluded that the urban schools (GSO-B) clearly outperformed the rural school (GSO-P) in terms of overall mean scores and statistical differences within STAT question categories. Furthermore, we found statistical difference between genders. We found interactions within STAT question categories group VI type questions (mentally visualizing 3-D images based on 2-D information). This category will receive particular future emphasis in curricula designed to build spatial thinking ability. The conclusions drawn from the research are that although we made a few minor adjustments to STAT to fit the Rwandan cultural context, the components of spatial thinking in the STAT provided utility for quantitatively validating our project hypothesis. Urban versus rural and gender differences are both common variables for comparing school student types. The work presented here presents the first work looking at these distinctions in the context of spatial thinking ability in Rwandan secondary schools. Thus, other researchers interested in using the STAT as spatial thinking ability measurement device can draw upon the experiences and results presented in this article for making modifications to the STAT in support of spatial thinking ability assessment in other cultural contexts.

Note

1. A copy of the final, modified STAT used for our baseline study can be downloaded from *http://people.rit.edu/~bmtski/rw_stat/STAT_baseline_July_2013.pdf* (STAT (c) Association of American Geographers (AAG); Dr. Jongwon Lee, STAT author).

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