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AN EVALUATION OF SERIOUS GAMES AND COMPUTER-BASED LEARNING ON STUDENT OUTCOMES IN UNIVERSITY LEVEL GEOGRAPHIC EDUCATION

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Abstract

We examine the effects of completing 'serious game' and computer-based learning assignments upon learning outcomes for undergraduate university students in an introductory human geography class (n = 177). The students completed one of the two experimental assignments as well as a control assignment that did not involve gaming, gathering data, or a computer. The groups were contrasted on their own evaluation of the assignments as well as their performance in multiple class outcomes. Our analysis found few significant differences between the group's self-evaluations of the assignments, their performance on the assignments, or their overall class grade. However, the 'control group' of students, who completed the control versions of the activities, performed significantly ($p > .05$) better on topic-relevant questions on the midterm (86% correct vs. 75%) and final examinations (94% vs. 87%). We conclude that completing the pen and paper version of the assignments resulted in better understanding of subject material.

Keywords: *Geography, Pedagogy, Serious Games, Computer-Based Learning, Digital Game Based Learning, web-based learning.*

1. INTRODUCTION

Educators at all levels are always searching to improve their student learning, especially when these improvements are simple and inexpensive to implement. In this project, we tested two different improvements to an established University-level undergraduate survey course in the subject of Human Geography. We modified two paper-based assignments for roughly half of the students and tested the effects of this change on their own evaluation of the assignments and their performance in a number of areas, including short answer questions on the assignments, and multiple choice questions about related concepts on the midterm and final examinations. The assignments were modified following on two popular concepts in education: computer-based learning and the use of a 'serious game' (also computer based). Our research question formally

stated is, what are the effects of completing a computer-based assignment or a serious game assignment on students' evaluation of the assignments, their performance on the assignments, and their performance on relevant portions of the midterm and final examinations? In this paper, we will discuss the research behind the concepts of computer-based learning and serious gaming. We will then detail the methods of our experiment, the results, discuss their implications, and conclude with some further thoughts.

2. LITERATURE

Higher Education institutions spend a significant part of their budget on technology to support and enhance pedagogy (Bowen 2012; Miller-Cochran and Gierdowski 2013). These expenditures are designed to enhance learning outcomes, as well to enhance universities 'prestige' and attract new students (Davis Education Foundation 2012). They are also often touted as long-term cost-saving measures, although there is little empirical research about this (Bowen 2012; Flavin 2016). Research concerning the effect of technologies on student learning outcomes is mixed and contradictory (Macedo-Rouet et al. 2009) and despite these mixed results, institutions continue to commit precious resources to them. This signals a clear need for more, and more rigorous testing of technology-based learning. Technological improvements in higher education are diverse and persuasive, and beyond the scope of this article to discuss in full. In this section we will focus on the literature concerning the enhancements we evaluated in our experiment: computer or web-based teaching materials, and the use of 'serious games'.

2.1 Computer Based Learning

Computer and web technology can replace or enhance paper-based education materials in diverse ways. Macedo-Rouet et al. (2009) conducted a thorough review of the literature on the topic, categorized by the type of enhancement or activity, and found mixed results throughout. The majority of research found no significant effects, or significant positive and negative effects for different outcomes within the same paper. Specific to this experiment, they found mixed results for the use of web vs. paper based materials, concluding that "students identify both positive and negative aspects of Web-based educational materials" and found no clear trend as to effect on learning itself (Ibid.). We should note that they performed an experiment of their own, in which the 'control' group of paper-based materials students performed better than the experimental group.

Other, more recent research continues to show mixed results using computer-based learning, with some studies noting improvement in student learning outcomes (Burch 2010; Johnson and McKenzie 2013) or student perceptions of the homework (Demirci 2010), while others found no or even negative results on learning outcomes (Demirci 2010) and student enjoyment (O'Connell and Dyment 2016).

2.2 Serious Games

Teaching students through games or play is not a new concept, and one that many teachers, especially primary and secondary teachers, use extensively. Using digital or 'video' games to teach has increased as these technologies have become ubiquitous, especially among younger students (Plass, Homer, and Kinzer 2015). Digital games that are designed primarily for educational are

referred to as 'serious games', or 'game-based learning', in the educational literature (Breuer and Bente 2010; Susi, Johannesson, and Backlund 2007). The advantages of using serious games are usually defined as: increased motivation (be it through the entertainment of the game itself or added 'trophies' or incremental achievements common in digital games); increased student engagement, the games potential adaptability to individual students, and 'graceful failure': allowing participants to 'fail' but not disengage from the activity (Plass, Homer, and Kinzer 2015). Commonly cited negatives are: negative mental health outcomes, including addiction to gaming or the internet, and negative physical health associations such as lack of physical activity, and obesity (Ballard et al. 2009; Ballard 2011; Fountaine et al. 2011; Mitchell and Savill-Smith 2004; McKetta and Rich 2011; Morahan-Martin and Schumacher 2000; Van Rooij et al. 2011; Wu et al. 2015). The research cited here encompasses digital games, internet use, and any 'screen-time'. Few, if any, studies have specifically examined only serious games in regards to these negative outcomes.

The evidence regarding the effectiveness of these games had been mixed and contradictory, with some research finding increased learning outcomes, others finding no significant results, and some negative results (Wouters 2013; Vogel et al. 2006). This contradictory evidence extends even to student's enjoyment of the serious games themselves (Hauk and Segalla 2005). This research is complicated by broad definitions of what constitutes a 'game', varying methods of evaluation, the extent to which the evaluated games have been designed with learning in mind, (Clark et al. 2010; Ke 2009; Mitchell and Savill-Smith 2004; Plass, Homer, and Kinzer 2015).

3. METHODS

3.1 Description of the Class

The study looked at students in the introductory human geography course in the geography department of the University of California, Santa Barbara. The course is entitled "People, Place and Environment" and is described in the course catalog as a "Survey of spatial differentiation and organization of human activity and interaction with the Earth's biophysical systems. Sample topics include human spatial decision-making behavior, migration, population growth, economic development, industrial location, urbanization, and human impacts on the natural environment." This one-trimester course provides students with the basic information and concepts of human geography and is an important component of the undergraduate education offered at the department. Of the three baccalaureate options offered, it is a requirement of the B.A in geography major, the B.S. in physical geography major and can be used to fulfill a requirement in the B.S. with a geographic information science emphasis major. The course requires no prerequisite and has a relatively large enrollment, usually between two and four hundred students. There is typically a broad spectrum of students enrolled in the class, including entry-level undergraduates with an interest in geography and similar subjects, as well as students from other disciplines. The students enrolled in this course were fairly representative of the wider undergraduate population of the university.

3.2 Experimental Design and Methods

Students in this class are required to complete six assignments during the course. For our project we created new versions of two assignments, one on the topic of political redistricting, which we consider connected to the larger subject of political geography, and the second on population pyramids, part of the subject of population geography. There were three teaching assistants (TAs) for this course, each with a number of 'laboratory sections' of students that they met with. Each TA gave some of their sections the computer-based or serious-game version of one assignment, and the paper version of another, so that in effect each student was in both the 'control group' and the 'experimental group' for one of the two assignments. Due to the vagaries of student attendance there were a few students who completed both experimental assignments or both control assignments, which should not affect our results. This design ensures that there is no difference between the experiment and control groups and also prevents one group of students from being disadvantaged by participating in the experiment. After completing each assignment, be it control or experiment, each student completed an anonymous in-class evaluation of the assignment. Each TA scored their particular students assignments, to maintain the variability present during the normal grading process. Students performance outcomes were collected during the trimester, and then made anonymous after the semester was complete.

3.3 Serious Games Assignment

The serious games assignment (Appendix A) involved the students reworking political districts based on party affiliation, race, and other considerations. In the paper-based control version students were given a grid with symbols representing different groups which they were asked to re-draw. In the electronic version, students were sent to the website http://www.redistrictinggame.org where they played the first four levels of online game that required them to redraw district lines, again based on party affiliation, race, and similar other considerations. This game was designed as a serious game, by a multi-disciplinary team of educators, researchers, and digital game professionals at the University of Southern California (http://www.redistrictinggame.org/about.php). It incorporates a number of the activities that theorists believe give games an advantage: problem solving, exploration, adaptability, requiring active participation, and allowing for 'graceful failure' (Kiili 2005; Mitchell and Savill-Smith 2004; Plass, Homer, and Kinzer 2015). The online game is noticeably different from the paper-based assignment in that it is dynamic, providing information about the new districts as they are changed, and that to complete the levels students must balance more factors than the paper-based version. Students also commonly had to create multiple versions of the districts to complete each level. As well, the game provides students with instant positive or negative feedback about how they completed (or failed to complete) each of the requirements for the new districts. In contrast, the paper-based version requires creating only one new districting scheme and feedback was provided later by the TA. For both versions, the graded portion of the assignment requires students to respond to several short answer questions. The final three short answer questions for both versions of the assignment are identical, and require the students to offer opinions about redistricting, as well as apply knowledge about the larger module of political geography to the particular topic. Students began the computer-based version in a computer lab (different than their normal classroom) and were given one week to complete it. For the paper-based version, the TAs

reviewed the assignment with the students, but they did not begin working on it in class. They were also given one week to complete it.

3.4 Computer-Based Assignment

The computer-based assignment (Appendix A) concerned population pyramids, a common graphing method in population research. In the computer-based version the student must search for and procure from www.census.gov some data necessary to create population pyramids for four countries, interacting with an online database in the process. They then must manually enter the statistics into a simple JavaScript application that creates these graphs and allows them to display the county in question on a simple world map. This application was created for this project. In the paper-based version they are given the statistics for four countries and draw the pyramids themselves. They then must use the graphs to answer five short answer questions, which are identical for both assignments. For both assignments, students were given instructions on how to complete the assignment by the TA, but they did not begin working on it in class, and were given one week to complete it.

3.5 Student Evaluations

Directly after turning in their completed assignments (before grades or feedback were received) the students were asked to complete an anonymous evaluation. These evaluations (Appendix A) had six, four-item Likert-scale questions that were identical across all assignments (1-6). The evaluations also contained a few assignment-specific Likert-scale questions and open-ended questions, used to add some qualitative depth to our understanding of the student's experience. The six universal evaluation questions asked to what level they agree or disagree with statements concerning the assignments': level of effectiveness in learning the relevant concept, the difficulty, whether it was intellectually stimulating, enjoyable, clear, and how much time was needed to complete the assignment.

3.6 Examinations

Each of the two main exams for the class contained multiple-choice questions about concepts related to these assignments. There were four questions on the midterm related to population geography and two questions related to political geography on the final.

4. RESULTS

4.1 Student Evaluations

We compared the students' responses between both pairs of experiment and control assignments (N=177) to the six identical Likert-scale style questions using Pearson's Chi-square. All statistical operations were performed using SPSS version 22.0 (IBM Corp.). For each of the two pairs of assignments, there was only one statistically significant ($p > .05$) different response between the control and experiment assignments. For the serious game version of the political geography assignment students were more likely to **agree** with the statement "The lab was effective for

helping me to understand the key concepts related to redistricting", with a difference in mean score of 0.34 (possible score ranges were 1.0-4.0)[1]. For the computer-based version of the population geography assignment the students were more likely to **disagree** with the statement "I enjoyed this lab" (mean difference of .30). After reviewing student's answers to the open-ended questions, it seemed that students did not enjoy the computer-based activities more than the paper-based activities, even the serious game activity. Also, there was a consistent desire was for shortest, easiest assignment, regardless of the format.

4.2 Performance on Assignments

We compared the students' performance (grades) on their assignments in a number of ways, using independent samples T-Test on mean scores. In no cases did we find any significant ($p > .05$) differences between groups. We found no statistically significant difference between control and experiment groups performance on: the individual questions of the assignments being evaluated, total score for the evaluated assignments, nor their mean score for all six class assignments combined.

4.3 Performance on Midterm and Final Exams

On each of the two main exams (midterm and final) for the class there were multiple-choice questions concerning the topics of the evaluated assignments (Appendix A). There were four population geography related questions on the midterm, and two political geography related questions on the final, out of approximately 50 multiple choice-questions (these multiple choice questions were the entirety of both exams). Completing any of the control or experiment assignments was associated with no statistical significant difference in their total mean midterm nor final scores, again tested using an independent samples T-Test. We also compared whether student's completion of either the control or experiment version of an assignment was associated with a significant difference in the mean probability of getting the population geography or political geography questions correct. On both the midterm and the final the **control groups performed significantly better** on the relevant questions, achieving a mean percentage correct of 85 versus the experiment groups' 76 on the midterm and a mean percentage correct percentage of 94 for the control versus 87 on the final (Figure 1).

[1] Created by assigning question options 1-4 points based on their order.

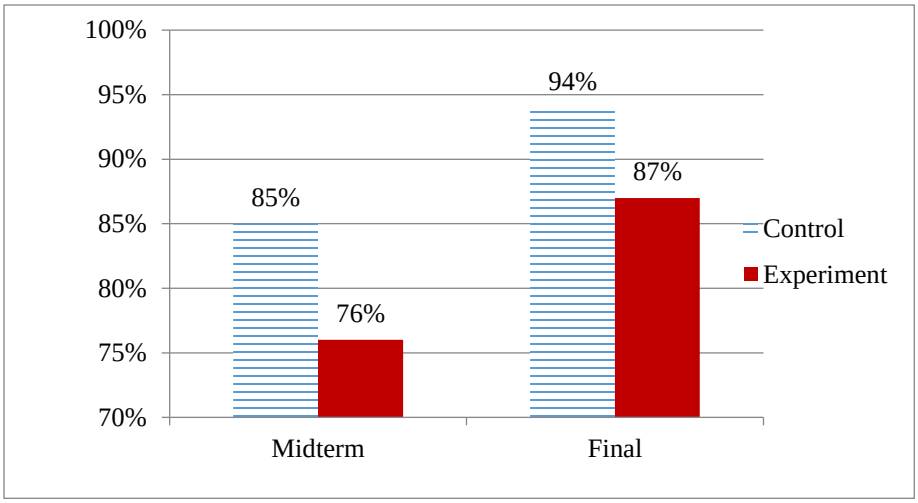

Figure 1. Mean Midterm and Final Results for Subject Relevant Questions.

In summary, students did not evaluate the different sets of activities as significantly different on the gross majority of evaluation questions. Students performed no differently on the activities themselves, or other class activities. Students who completed the control (paper-based) versions of the activities performed significantly better on the midterm and final questions related to those topics.

5. CONCLUSION

The results of our study are unambiguous. Our two experimental assignments, both of which were web or computer based, and one of which incorporated a serious game, did not result in any improvement in student's perception of the activities or their learning outcomes. Here, we theorize explanations for these results before attempting to draw some larger conclusions.

First, it is very possible that the experimental assignments did not fail on a technological or conceptual level but were simply just not of high quality; although we did attempt to make the control and experimental versions as similar as possible (full versions of all 4 assignments are included in Appendix A). Alternatively, perhaps they did not go far enough. The literature has noted some difficulties in successfully implementing these techniques, and, especially with serious games, note that the activities should achieve some minimum standard of fun or challenge if they are to achieve the purported benefits of engagement and increased motivation. We created the web-based assignment ourselves (using the U.S. Census's website, which seems functional and well designed) and the serious game activity was not particularly long or 'immersive' (although it was created by established researchers and digital game professionals). Perhaps we did not meet the minimum standards to allow these techniques to improve learning. Although, we would argue that if 50-100 hours of seasoned educator effort combined with the use of these well-established materials is not enough effort to create improved learning outcomes for these techniques than that is of concern in and of itself.

It is also possible our experimental design caused imperfections; perhaps the TAs grading the assignments (who were unavoidably able to distinguish between the versions) acted with some bias that distorted the differences between them. It is also possible that short answer questions, graded on scale between zero and four total points are too crude a measure, and suppressed

differences. Perhaps more significant differences would have revealed themselves if we had given the students essays on the topics rather than short answers. Although, given that the only significant difference in performance was for the paper-based group, we might expect any distorted or suppressed difference to still favor that group.

The higher performance from students who completed the paper-based assignments could also be an indicator of benefits of using written materials. It is possible that completing these computer-based assignments, as simple as they were, added a degree of difficulty that hindered some students, which would be consistent with other work (O'Connell and Dyment 2016). The only significant differences were found in the assignment-related questions on the examinations, which were paper-based. It is possible that the students received some boost in recall due to their use of paper assignments, a form of 'context-dependent memory' (Koens 2003; Smith and Vela 2001). Another possibility is that the increased scores on the examinations is a function of different cognitive processes. The students were compared on short essay questions in the assignments, which we perhaps flatter ourselves in saying required higher-level cognitive processes such as understanding, applying, evaluating, and synthesizing; whereas the examination's multiple-choice questions could have required lower-level cognitive processes such as recall and recognition. Perhaps the repetition of the pen and paper assignments led to better memorization, and therefore better performance on the recall and recognition tasks.

It is also possible that paper-based assignments, or at least these paper-based assignments, simply produce better outcomes in students. This was the case in a number of previous studies discussed in the literature portion of this paper. Regarding the similarity in student evaluations across the control and experiment groups, students are not necessarily looking for entertainment in their education, and other studies have shown that efficiency was more of a concern for some students (Mitchell and Savill-Smith 2004). In our student's open-ended responses students expressed a desire for the shortest (and easiest) assignments. We certainly don't believe that our experiment has settled this debate, but it certainly allows us to say that technology in education is not a panacea: Quality teaching is irreplaceable, even if it does not increase admissions or look good in a brochure.

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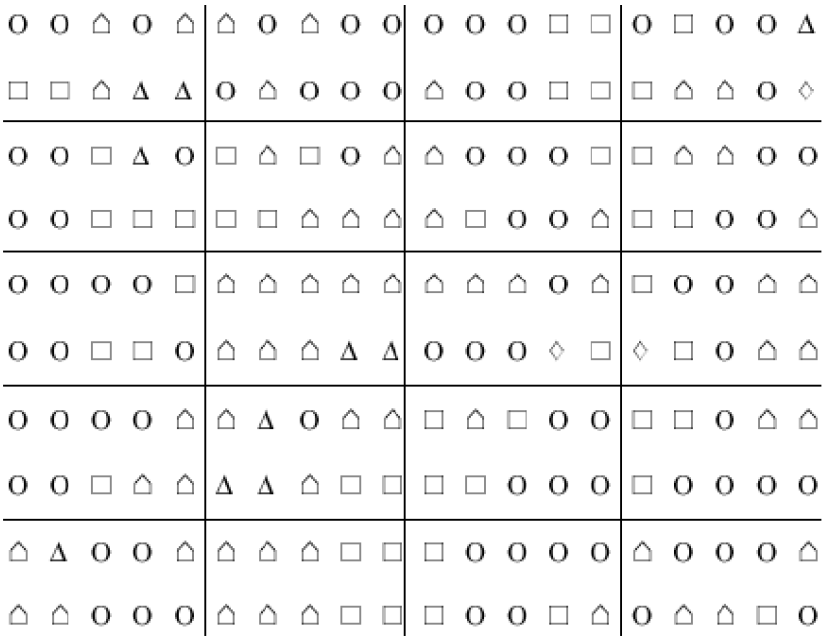
APPENDIX A.

Serious Games Assignment, Control Version.

Directions: Complete the activities below and then answer the questions at the end of the assignment for credit. Use the blank spaces to answer the questions, or turn in a separate sheet.

Part 1: This chart represents where various voters live in the town of Athena. The town council has divided the town into 20 voting districts in a way that they think is fair and simple.



Town of Athena Population: 200,000 Voting Districts: 20 Voters per District: 10,000
Note: Each symbol equals 1,000 voters.

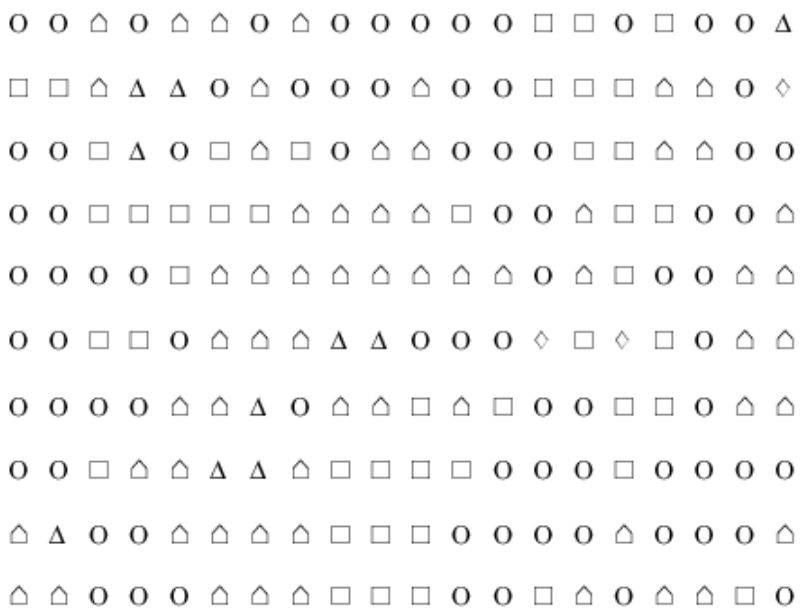
African Americans	□	Asian Americans	◇
American Indians	Δ	Hispanics	⌂
European Americans	O		

Question 1: How many districts in this map are dominated by a majority of people of one race or ethnicity? *2 points.*

Question 2: Do those districts fairly represent the size of that racial or ethnic population in the city? Why or why not? *3 points.*

Question 3: Assume that African Americans and American Indians vote for the Democratic party 90% of the time, European Americans Republican Party 70%, Asian Americans 50-50, and Hispanics 60% Democratic. How many districts will each party win under this plan?
Republican - Democrat - *2 points.*

Part 2: Divide the town into 20 voting districts in a way that is fair and equitable. You may base this on race, geography, voting preference, or personal choice.



Question 4: Explain the rationale behind your scheme and the racial and political groupings that resulted: *4 points.*

Question 5: Do you think it is fair to make new districts, or non-compact districts, to ensure that African –Americans have a majority district? Why or why not? Does it matter that African – Americans almost always vote democrat? *3 points.*

Question 6: Why is redistricting so important in politics? *3 points.*

Question 7: Why is redistricting a fundamentally geographic issue? 3 points.

Serious Games Assignment, Experimental Version.

This assignment concerns political redistricting, a common but contentious process in many democracies. This process happens continuously across the many political units that make up cities, counties, states and federal districts. It is even more common in years when new U.S. Census data becomes available, like 2011. This assignment should be completed in lab.

Instructions:

For this assignment we will be using an online flash game to illustrate the political redistricting process. Additionally, you will be responsible for answering the questions below. These questions should be answered in one or two paragraphs each. Your textbook has some material on this topic in Chapter 12, which can help you answer these questions, and there is additional information online.

Go to http://www.redistrictinggame.org/. Play levels 1 through 4 on advanced, and read the "Learn More" for each of the levels.

Answer the following questions:

1. Level 1 – Find an example from the textbook of a non-compact district. Where is it and what does it look like?. Why are the rules about non-compactness more difficult to enforce than the rules about contiguity? *4 points.*

2. Level 2- Define 'cracking' and 'packing' in your own words. *4 points.*
3. Level 3 – What is the bipartisan gerrymander and why is it a 'new twist' on gerrymandering? *3 points.*
4. Level 4 – Do you think it is fair to make new districts, or non-compact districts, to ensure that African –Americans have a majority district? Why or why not? Does it matter that African –Americans almost always vote democrat? *3 points.*
5. Why is redistricting so important in politics? *3 points.*
6. Why is redistricting a fundamentally geographic issue? *3 points*

Computer-Based Assignment, Control Version.

The size, growth, and composition of a country's population affect its economic and environmental well-being. Rapid population growth requires large commitments of natural resources for food, housing, education, and health care. It worsens problems of poor air and water quality, soil erosion, and so on. In cases of very rapid growth, a country will have a large population that is too young to provide support for themselves or others (i.e., there will not be enough adults to work). However, several countries are experiencing slow growth, stability, or even negative growth (population decline). In cases of negative growth, a country will soon have a large group that is too old to support its own members, let alone other segments of the population. Whether because of very rapid growth or negative growth, countries have trouble caring for large populations that require a great deal of health care, economic assistance, and the like. So it is clear that population composition is very important, not just population size. As discussed in class and in the text, the most common way to display population composition is a graph called a "population pyramid."

In this assignment, you will be given data on the age-sex composition for four countries. You will construct a population pyramid for each of these countries. Then you will answer a series of questions about the pyramids and the results of possible changes in population policy or reproductive behavior. Use a ruler to draw population pyramids for countries A-D, one on each template. Here are the data for each country, in percentage (%) of population:

Age Group	Country A		Country B		Country C		Country D	
	Female (%)	Male (%)	Female (%)	Male (%)	Female (%)	Male (%)	Female (%)	Male (%)
0-4	6.5	7.0	16.6	17.2	11.6	12.2	4.5	5.4
5-9	6.3	6.8	14.7	15.2	10.9	11.4	4.2	5.1
10-14	6.9	7.5	12.4	12.8	10.4	10.6	3.9	4.7
15-19	6.9	7.6	10.8	11.0	9.9	10.0	4.5	5.5
20-24	6.8	7.4	9.1	9.1	9.4	9.3	7.1	8.5
25-29	6.5	6.8	6.8	6.7	8.8	8.6	7.6	8.9
30-34	6.5	6.8	6.0	5.7	7.7	7.6	6.5	7.5
35-39	6.9	7.2	5.2	4.9	6.6	6.5	6.6	7.6

40-44	7.6	7.8	4.4	4.2	5.6	5.5	6.7	8.0
45-49	7.6	7.6	3.6	3.5	4.7	4.6	6.9	7.7
50-54	6.8	6.8	2.9	2.8	3.9	3.9	7.5	7.7
55-59	6.0	5.9	2.1	2.1	3.2	3.1	6.7	6.3
60-64	4.6	4.3	1.7	1.6	2.6	2.5	6.2	5.3
65-69	3.6	3.3	1.5	1.3	2.0	1.8	5.2	3.8
70-74	3.1	2.7	1.1	0.9	1.4	1.2	6.0	3.9
75-79	2.9	2.2	0.6	0.5	0.8	0.7	4.4	2.3
80-84	2.3	0.7	0.3	0.2	0.4	0.3	3.3	1.4
85-89	1.4	0.2	0.1	0.1	0.1	0.1	1.9	0.4
90+	0.8	0.0	0.0	0.0	0.0	0.0	0.6	0.1

To Turn In (next week in section)

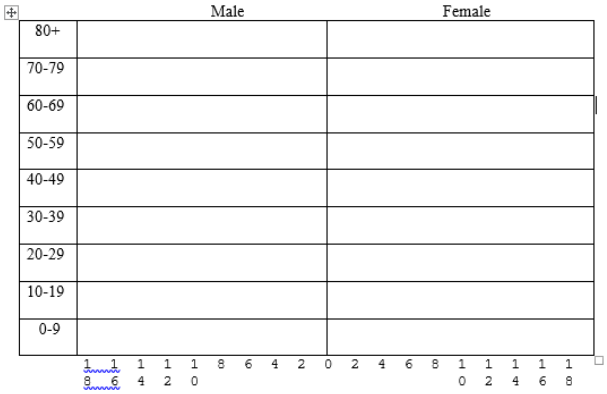
Your four pyramids. *4 points.*

Typed answers to the following questions:

1. Describe the age-sex composition for each country, in words. *4 points.*
2. If we assume that a woman's childbearing years are from 15 to 49, what percentage of the females in each country can potentially have children? What do you think this means in terms of the potential growth rate in each country? Rank order the four countries in terms of their potential growth rate. *3 points.*
3. What do you think the standard of living will be like in each country in 20 years? *3 points.*
4. Suppose that the government of each country passes a law restricting each couple to having no more than 2 children. The penalties are severe, so nearly everyone follows the law. Describe how each pyramid will look different in 20 years. Even though 2 children/woman is a little less than the replacement rate, will the population necessarily stop growing or even shrink soon after this law is in place? Why or why not? *3 points.*
5. For each pyramid name one country in the world that might be represented by the pattern shown in the pyramid. Explain why you chose each country. *3 points.*

For more information about population pyramids, here is a short video on the topic: http://www.youtube.com/watch?v=sSoSYm4AOls&feature

Population Pyramid Templates



Computer-Based Assignment, Experimental Version.

The size, growth, and composition of a country's population affect its economic and environmental well-being. Rapid population growth requires large commitments of natural resources for food, housing, education, and health care. It worsens problems of poor air and water quality, soil erosion, and so on. In cases of very rapid growth, a country will have a large population that is too young to provide support for themselves or others (i.e., there will not be enough adults to work). However, several countries are experiencing slow growth, stability, or even negative growth (population decline). In cases of negative growth, a country will soon have a large group that is too old to support its own members, let alone other segments of the population. Whether because of very rapid growth or negative growth, countries have trouble caring for large populations that require a great deal of health care, economic assistance, and the like. So it is clear that population composition is very important, not just population size. As discussed in class and in the text, the most common way to display population composition is a graph called a "population pyramid."

In this assignment, you will extract data from US Census website and use it to analyze the age-sex composition of four countries. You will use a Java-based application that we have designed to create population pyramids for four countries and then answer a series of questions. Most people's personal computers should be able to run with program. If you are having difficulty using this program on your personal computer, than please try the computers in the Geography department's laboratories or the other computers located around campus.

Instructions for getting your data:

1. Go to the following link www.census.gov/population/international
2. Click on the Data tab in the middle of the page and then on the International Program (IDB) link. This will open a new page.
3. In the "Select Report" section on the left chose the "Population by Five year age group" option.
4. Get the data for the following four countries and years:

United States, 2012 Guatemala , 2012 India, 2012 Latvia, 2012

5. Use these data to create your four separate graphs in the next section.

Instructions for creating your graphs:

6. Go to GauchoSpace and download the folder "PopPyramidGeog5". Place this folder somewhere easy to access before you begin.
7. Open the file "poppyramid". This will launch the application.
8. Fill in your personal information along the bottom of the application.
9. Use the map on the left of the application to display your country. This map is manipulated by using the right mouse button.
10. Use the data from www.census.gov to fill in the data fields on the right. Make sure you enter at least one number after the decimal, even if it is a 0. Then click "Add Data". Review your fields to ensure that these numbers are correct. Then click "Re-Plot", which will update the population pyramids to include your new data. Note: once you hit the "Re-Plot" button if you want to make changes to this data you have to reset the data fields, so make sure that these numbers are correct.
11. If your graph looks the way you want it to hit "Save". This will automatically create an image file called "MyPyramid_PLEASE_CHANGE_MY_NAME". Make sure you change the name of this file immediately, otherwise it will be saved over by the next graph.
12. Push the "Reset" button to clear the data fields. Redo this process for your next three countries.

To Turn In:

Your four population pyramids. *4 points.*

Typed answers to the following questions:

1. Describe the population pyramids for each country: what is the distribution like across the age groups? Are there noticeable sex differences? *4 points.*
2. For each pyramid, what pattern of growth does this best represent? Explain why you chose this pattern. *3 points.*
3. If we assume that a woman's childbearing years are from 15 to 49, what percentage of the females in each country can potentially have children? What do you think this means in terms of the potential growth rate in each country? Rank the four countries in terms of their potential growth rate. *3 points.*
4. What do you think the standard of living will be like in each country in 20 years? *3 points.*
5. Suppose that the government of each country passes a law restricting each couple to having no more than 2 children. The penalties are severe, so everyone follows the law. Describe how each pyramid will look different in 20 years. Even though 2 children/woman is a little less than the replacement rate, will the population necessarily stop growing or even shrink soon after this law is in place? Why or why not? *3 points.*

For more information about population pyramids, here is a short video on the topic: http://www.youtube.com/watch?v=sSoSYm4AOls&feat

Student Evaluation Forms, Combined.

Please indicate how strongly you agree or disagree with the following statements:

1. The lab was effective for helping me to understand the key concepts related to (redistricting or population pyramids).

a. Strongly agree
b. Agree
c. Disagree
d. Strongly disagree

2. I found this lab to be difficult.

a. Strongly agree
b. Agree
c. Disagree
d. Strongly disagree

3. I found this lab to be intellectually stimulating.
a. Strongly agree
b. Agree
c. Disagree
d. Strongly disagree

4. I enjoyed this lab.
a. Strongly agree
b. Agree
c. Disagree
d. Strongly disagree

5. How clear were the instructions for this lab?
a. Very clear
b. Somewhat clear
c. Somewhat confusing
d. Very confusing

6. How much time did you spend on this laboratory assignment?
a. 1-2 hours
b. 3-4 hours
c. 5-6 hours
d. more than 6 hours

7. Did you experience technical difficulties working through this lab?
a. Yes, many
b. Yes, a few
c. No

8. I found this assignment interesting because it (used real data or had a game).
a. Strongly agree
b. Agree
c. Disagree
d. Strongly disagree

9. I explored parts of the database (e.g. statistics, figures, attributes of countries) that were not required for this assignment.
a. Strongly agree
b. Agree
c. Disagree
d. Strongly disagree

10. What was your **least** favorite portion of this lab?
11. What was your favorite portion of this lab?
12. If you were in charge of re-writing this lab, what three things would you do to improve it?

Relevant Exam Questions.

Which of the following contributes MOST to both current and projected population growth?

a. decreasing crude birth rate
b. demographic momentum
c. decreasing total fertility rate
d. decreasing death rate

The _____ in the United States will greatly increase over the next couple of decades as baby boomers reach old age and are no longer able to provide for themselves

a. poverty line
b. population pyramid
c. doubling time
d. dependency ratio

A country at the end of demographic transition usually has which of the following?

a. high birth and low death rates
b. a high infant mortality rate
c. a high crude birth rate
d. low birth and death rates

A population pyramid that is very broad at the base and narrows rapidly towards the top is most likely representative of:

a. a country whose population is aging rapidly
b. a developing country experiencing rapid population growth
c. a country whose population has stabilized
d. a country that has experienced a baby boom some time in the past

Where does the name "gerrymandering" come from?

A. an early technique for setting maritime boundaries invented by Admiral Gerrymand
B. large demand created by geritol-consuming seniors
C. the large number of federal mandates controlling pollution by corporations
D. salamander-shaped voting district created by Governor Gerry

Redistricting is an attempt to:

A. adjust the boundaries of racially segregated school systems.
B. draw boundaries so that each voting district has about an equal number of voters.
C. end the overrepresentation of metropolitan areas in state legislatures.
D. establish districts that have roughly equal areas.