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Integration of face-to-face and virtual classes improves test scores in Biology undergraduate courses on days with flooding in Brazil

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ABSTRACT. Ubiquitous Education, omnipresent education, has established with the using of virtual learning objects, and integrating with the face-to-face classroom brought satisfactory results in the knowledge construction. In parallel, one of the recurring problems of cities is the traffic immobility and consequently the student's arrival to the University. In days of flooding, the student takes longer to get to university or sometimes cannot reach. This work has the hypothesis that the integration of face-to-face classes with virtual classes would be the option for the days of traffic immobility in cities. The objectives of this work were: i) to analyse the types of transport used by students from their homes to go to university, ii) to analyse how long students spent commuting from their homes to university, and iii) compare the results of student evaluations of biology courses that have lessons integrated between virtual and face-to-face classes with students who only have face-to-face classes. Six metropolitan areas of Brazil were evaluated for two semesters, one with flooding days and another without. The results indicated that students who had a virtual support of the discipline, mainly on flooding days, had higher grades and success in knowledge construction.

Keywords: rainfall, accessibility, u-learning.

Integração de aulas presenciais e virtuais influenciando nos resultados das avaliações em cursos de Biologia em dias com enchentes no Brasil

RESUMO. A educação ubíqua, educação onipresente, se estabeleceu com a utilização de objetos de aprendizagem virtual, e integrando com as aulas presenciais trouxe satisfatórios resultados na construção do conhecimento. Em paralelo, um dos problemas recorrentes das metrópoles é a imobilidade do trânsito e consequentemente da chegada do aluno à Universidade. Em dias de inundações, o aluno demora mais para chegar à universidade ou às vezes não consegue chegar. A partir daí, foi hipotetizado que com a integração de aulas virtuais com presenciais seria a opção para os dias de imobilidade do trânsito nas metrópoles. Os objetivos deste trabalho foram: i) analisar os tipos de transporte utilizados pelos alunos para irem de suas casas à universidade; ii) analisar por quanto tempo os estudantes gastaram de suas casas à universidade; iii) comparar os resultados das avaliações dos alunos dos cursos de Biologia, que têm aulas presenciais integradas com virtuais com alunos que só têm aulas presenciais. Seis regiões metropolitanas do Brasil foram avaliadas durante dois semestres, um com dias com inundação e outro sem. Os resultados indicaram que os alunos que tiveram um suporte virtual da disciplina nos principais dias de inundação tiveram maiores notas e sucesso na construção do conhecimento.

Palavras-chave: precipitação, acessibilidade, u-learning.

Introduction

Extreme climatic events, such as El Niño and La Niña, and the associated global climate changes have resulted in periods of enhanced dryness or concentrated and intense rainfall (SUAREZ et al., 2005). In urban centres, there is poor drainage due the number of buildings and reduced green areas to evacuate rainwater underground (SWAN, 2010). The rainwater runoff accumulates in public streets and roads because they are lower than the sidewalks (VILLARINI et al., 2010). Recordings of precipitation higher than 100 mm per day have increased worldwide, and the associated problems (KAŹMIERCZAK; CAVAN, 2011) have been reported in newspapers. For example, searches using the keyword 'flooding' per year in the search engine Google (Google Search) resulted in 32.5 million hits in 2007, 58.8 million in 2007, 44.6 million in 2009, and 81.1 million in 2010.

An estimated 3 billion people, 43% of the global population, are directly and indirectly affected by flooding (SUAREZ et al., 2005). A number of associated problems have been described in the literature including: i) direct risks, such as erosion (BERNATCHEZ et al., 2011) and destruction of public streets and roads (KAŹMIERCZAK; CAVAN, 2011); ii) indirect risks, such as traffic jams (SUAREZ et al., 2005) and food production losses (DANIEL et al., 2009); iii) health risks, such as leptospirosis (SOCOLOVSCHI et al., 2011) and dengue (LLEO et al., 2008); iv) social risks, such as thefts (DAWSON et al., 2011); and other problems.

Of all of the problems related to flooding in metropolitan areas, traffic jams were the most common one reported by newspapers. Traffic jams were reported in 96% of the news headlines (in searches for the word 'flooding' in 2010 using Google Search) and scientific papers on flooding (KAŹMIERCZAK; CAVAN, 2011; SWAN, 2010; SUAREZ et al., 2005). Traffic problems in a metropolis interfere with basic activities, including markets and public services, because absent employees lead to closures (DANIEL et al., 2009). These same problems occur with schools and universities when teachers and students are unable to travel to these educational sites. In countries with intense snowfalls during the winter, there are many reports of mobility problems (BERDICA, 2002). In Brazilian cities with populations higher than 500 thousand inhabitants, flooding causes mobility problems for educational institutions. For example, in Sao Paulo, classes are cancelled when the precipitation is higher than 90 mm per day (SILVA et al., 2008). These cancellations impair teaching and learning by preventing teachers from performing within the local and national school calendar, which is important for national and international evaluation (STREMEL; MAINARDES, 2011).

In countries with extensive periods of snowfall, one solution to mobility problems is the implementation of a virtual learning environment (VLE) in undergraduate courses so as to avoid losing the continuity of teaching, learning and student interaction (HARPER et al., 2004). This educational method was applied by companies for business education to reduce costs, time and the mobility of employees who required lifelong learning in periods with and without flooding (LOUVIERIS; LOCKWOOD, 2002).

The VLE permits teachers to add virtual classrooms and static learning objects, such as texts, and dynamic learning objects, such as videos. Additionally, the VLE allows the teachers to carry out simulations and virtual labs. The sum of these didactic sources with teacher-student and student-student collaboration and communication are important factors for the construction of knowledge (SCHWEIZER et al., 2011). For example, with biology undergraduate students, enhancing student contact with the content of courses in face-to-face and virtual environments resulted in an increase in test scores (SANTANA; PEIXOTO, 2010).

In this study, the hypothesis was that the group of students with the VLE in addition to face-to-face classes had higher test scores than the group of students without the VLE during a semester with days of flooding. Six metropolitan areas of Brazil were examined during two semesters, one with days of flooding and the other without. The objectives of this work were: i) to quantify and to analyze the types of transportation the students used to go from their houses to the university, ii) to quantify and to analyze how long the students spent going from their houses to the university, and iii) to analyze and compare the test scores of students in biology undergraduate courses that have face-to-face and virtual classes with the test scores of students taking courses that only have face-to-face classes.

Material and methods

This study was carried out in six of the most populous metropolitan areas of Brazil: Sao Paulo (SP), Rio de Janeiro (RJ), Belo Horizonte (BH), Porto Alegre (PA), Recife (RE) and Fortaleza (FO) (Figure 1 and Table 1). The data were collected in the following public universities situated in the cited regions: Federal University of Ceara (UFC), Federal University of Pernambuco (UFPE), Federal University of Minas Gerais (UFMG), Federal University of Rio de Janeiro (UFRJ), University of Sao Paulo (USP) and Federal University of Rio Grande do Sul (UFRGS).

Figure 1. Most populous metropolitan areas of Brazil. FO = Fortaleza; RE = Recife; BH = Belo Horizonte; SP = São Paulo; RJ = Rio de Janeiro; PA = Porto Alegre.

Table 1. Populations and areas of six of the most populous metropolitan areas in Brazil, the main universities in these areas and the total number of students attending these universities (IBGE, 2010).

Metropolitan area	ID	Population	Area (km^2)	University	Students
Sao Paulo	SP	19.681.716	7.944	USP	88,261
Rio de Janeiro	RJ	11.838.752	5.292	UFRJ	45,753
Belo Horizonte	BH	4.882.977	9.468	UFMG	39,070
Porto Alegre	PA	3.979.561	10.097	UFRGS	34,295
Recife	RE	3.688.428	2.769	UFPE	31,424
Fortaleza	FO	3.610.379	5.784	UFC	25,813

The online questionnaire (SANTANA, 2011) was available to students of these universities. The questions were: 1) Which type of transportation do you use to go to the university? and 2) How long do you spend going from your home to university? Other variables were sampled including the student's final test score and daily face-to-face presence in the classroom during two semesters of undergraduate biology courses in 2010.

Two sample groups were established. One group had face-to-face and virtual classes and the other had only face-to-face classes in their biology undergraduate courses. The two groups were evaluated during two semesters in 2010, one with flooding days and the other without.

The number of evaluated students was approximately 5% of the regular students at the evaluated universities (Table 1). The variables 'test score' and 'presence in face-to-face classroom' were quantified by the students taking biology undergraduate courses who agreed to participate in this study. The VLE used were blogs, websites, learning management systems (e.g., Moodle) or another virtual repositories of didactic sources (texts, videos, software, simulators, virtual labs, and others), virtual interaction (forums and chat rooms) and virtual management (evaluations, downloads, uploads, and others). An example of the instructional design and its VLE is shown in Figure 2.

The flooding days were determined by the height of accumulated water (> 50 cm of ground) during and post-rainfall in the main streets used to access the universities and in the exits of nearby subways and trains (KAŹMIERCZAK; CAVAN, 2011).

These data were confirmed by newspaper reports (Figure 3) for the years 1985, 1990, 1995, 2000, 2005 and 2010.

The non-parametric Mann-Whitney hypothesis test (5%) was carried out to compare the differences in the hours spent travelling from home to university in semesters with or without days of flooding and to compare the test scores of students during semesters with or without days of flooding. The significance level (p-value) was calculated. Regression analysis was carried out between the independent variable (x), the presence in classroom, and the dependent variable (y), the students' test scores. The analysis was performed in two groups: student with face-to-face classes only and students with both face-to-face and virtual classes.
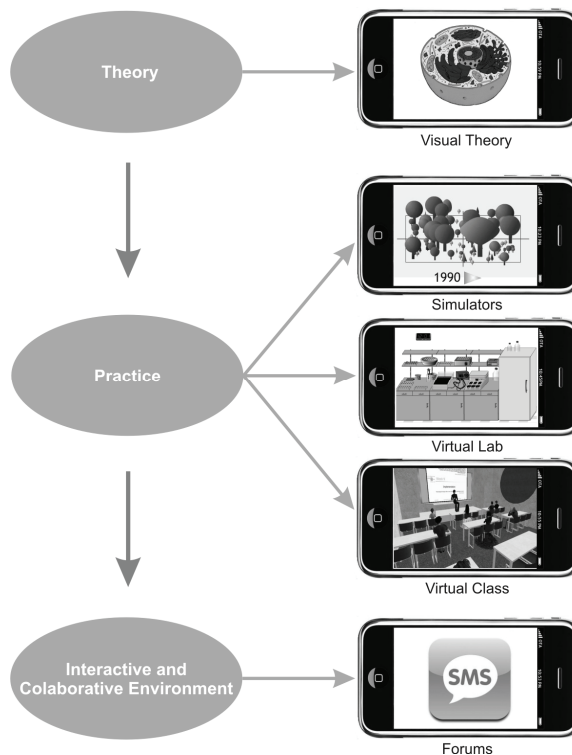

Figure 2. Examples of the instructional design and its VLE for the mobile phone courses at the Open University of Brazil (SANTANA; PEIXOTO, 2010).

Figure 3. Representative photographs of flooding days and the impact on public transport in Sao Paulo. Photographers: A) Almeida Rocha/Folha Imagem; B) Carlos Cesar Fracasso/FotoReporter/AE and C) Leopoldo Godoy/G1.

Results

The number of students that answered the questionnaire was approximately 5% of the total students (Table 2). An average of 212 (± 52) biology students were evaluated for their test scores and presence in the classroom.

Table 2. Number of evaluated students, percentage of total students that participated in the study and the number of students in each group.

Metropolitan area	University	Evaluated Students	% of total	Groups	
				FF	FF + VLE
Sao Paulo	USP	3,795	4.3	256	244
Rio de Janeiro	UFRJ	2,607	5.7	254	203
Belo Horizonte	UFMG	1,777	4.5	219	203
Porto Alegre	UFRGS	1,697	4.9	218	193
Recife	UFPE	1,759	5.6	202	182
Fortaleza	UFC	1,368	5.3	193	177

FF = face-to-face classes; FF+VLE = face-to-face and virtual classes.

Most of the time, the students went from home to university by using public transportation (75% ± 10%) in the evaluated metropolises (Figure 4). Mainly, the students used buses (54 ± 6%), followed by subways/trains (21 ± 10%), private cars and motorcycles (14 ± 8%), taxis (6 ± 1%), bikes (4 ± 4%) and walking (1 ± 3%). In the most populous metropolises (SP and RJ), fewer students used ecological transport options, such as bikes and walking, than the least populous metropolis (FO) to go to the universities. Some transportation options had no responses, such as taxis in FO and walking in SP.
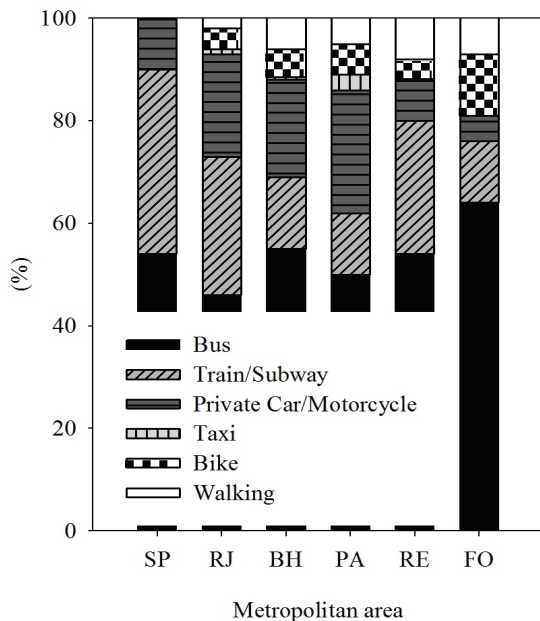
Figure 4. Responses, given in percentages, regarding the types of transportation used to travel from home to university in the six studied metropolitan areas. SP = São Paulo; RJ = Rio de Janeiro; BH = Belo Horizonte; PA = Porto Alegre; RE = Recife; FO = Fortaleza.

The number of days of flooding increased on average by 34% from 1985 to 2010 (Figure 5).
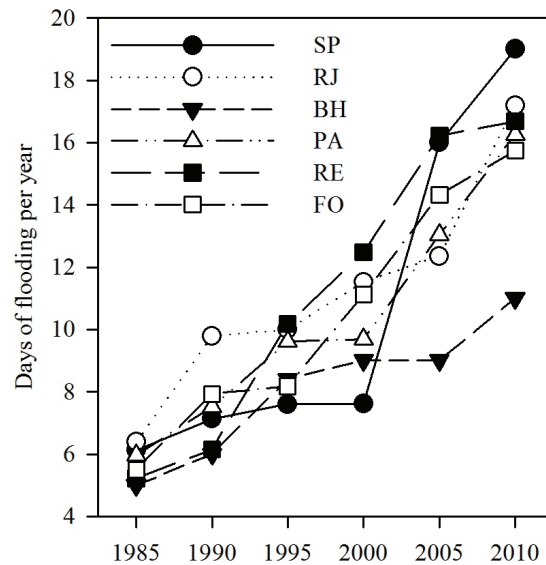
Figure 5. Days of flooding per year from 1985 to 2010 in six metropolitan areas of Brazil. SP = São Paulo; RJ = Rio de Janeiro; BH = Belo Horizonte; PA = Porto Alegre; RE = Recife; FO = Fortaleza.

In BH, there was a 26% increase in days of flooding, which was less than the average. On average, the students spent 1.24h (± 0.83) travelling from home to university on days without flooding and 2.54h (± 0.52) on days with flooding, and this difference was significant ($p < 0.0001$). In PA and RE, students spent approximately 2h longer to travel to university on days with flooding than on days without flooding. In SP and RE, the standard deviation for the time spent travelling to the university was > 0.5h on days without flooding, and for all evaluated metropolises, the standard deviation for the time spent travelling to the universities was > 0.5h on days with flooding (Figure 6).

There was a significant difference in the presence of students at the university in periods with flooding compared to periods without flooding ($p < 0.0125$) (Figure 7). On days without flooding, 77% of students were present at the face-to-face classroom, whereas on days with flooding, 27% of students were present.

The data showed a significant, direct, linear proportionality ($R^2 > 0.78$, $p < 0.0001$, error < 0.0231); (Figure 7) between the variables for test scores and student presence at the classroom. In the evaluated semester in 2010 that had up to 10 days of flooding, the group of students with only face-to-face classes had a lower average test score (5.1 ± 0.5; $p < 0.0001$) than in the semester without flooding (7.5 ± 1.3). This difference was 33% on average. The group with face-

to-face and virtual classes did not have a significant difference (p = 0.6512) in test scores between the semester with flooding (7.4 ± 0.6) and the semester without flooding (7.5 ± 0.9).
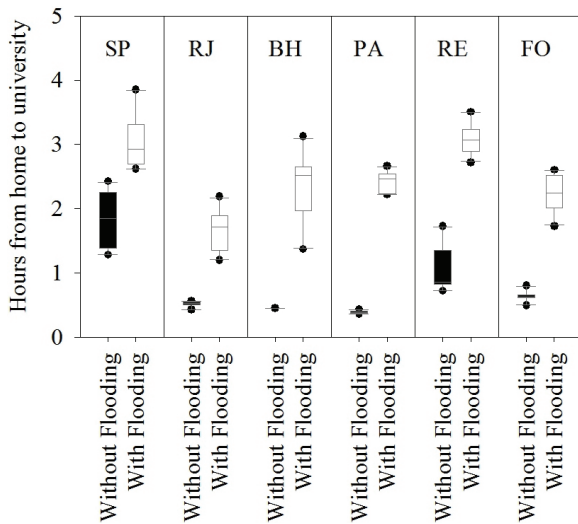

Figure 6. Average and statistical deviations of the time students spent going from their homes to universities. Black box: without flooding and white box: with flooding. SP = São Paulo; RJ = Rio de Janeiro; BH = Belo Horizonte; PA = Porto Alegre; RE = Recife; FO = Fortaleza.
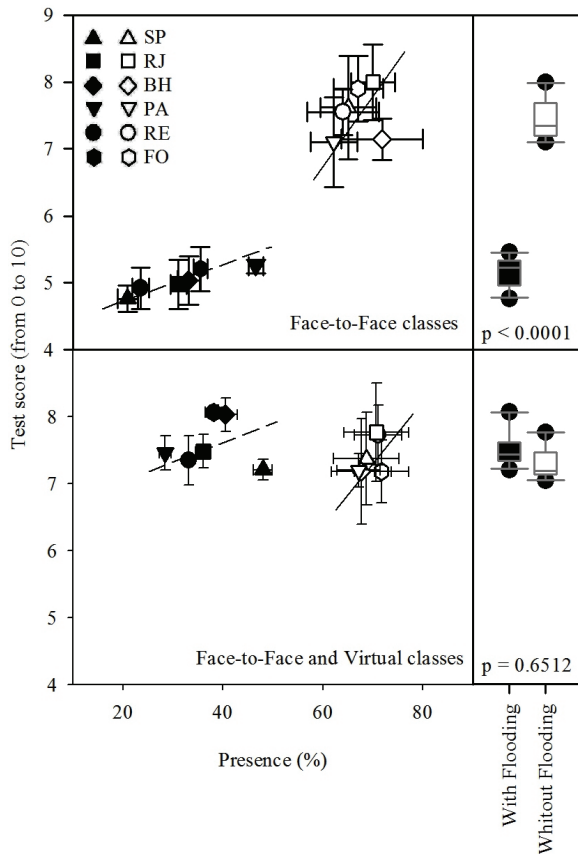

Figure 7. Relationship between final test scores and presence at classes of the evaluated students in six metropolitan areas of Brazil.

Discussion

In this study, the results demonstrate that the group of students with the VLE in addition to face-to-face classes had higher test scores than the group of students without the VLE during a semester with days of flooding. The number of students sampled in this study was satisfactory with respect to the total population of students at the evaluated universities. Approximately half of the data from the questionnaires and evaluations had a normal distribution for each variable. This result was similar to previous research that used this analysis method (CHAUDHURI et al., 2005).

In countries with high economic development, up to 87% of the total mobility in the urban centre relies on the utilization of public transportation (SILVA et al., 2008). In Brazil, the quantitative and qualitative problems with public transportation and the subsidies for owning private cars and motorcycles (12% reduction of taxes to purchase) does not provide an incentive for the use of public transportation (IBGE, 2010). Biking or walking represents < 0.1% of conventional transportation in São Paulo (SILVA et al., 2008).

Intense, concentrated rainfall combined with low drainage in metropolis areas is a common problem worldwide (NICHOLLS, 2004). The data confirmed that it is necessary to invest in improving rainwater drainage. In Brazil, the metropolitan regions increase building areas by 25% each year (SANTANA; PEIXOTO, 2010) producing a significant impermeability of the soil (VILLARINI et al., 2010).

On days with flooding, the water blocked transit on the streets, causing significant delays or impediments to mobility. The 33% of student that lived near (< 2 km) the university went to class during these periods, but most students stayed home. In Brazilian cities, the government recommends that students do not attend university on days of flooding because of accessibility problems and as a precaution to avoid landslides (GOMES et al., 2008).

Flooding implies problems for the education system. The period of contact with the content of the course, including classes, learning objects, and teacher-student interactions, is a main factor that contributes to successful test scores (SANTANA; PEIXOTO, 2010). Flooding reduces this period of contact, resulting lower test scores. The students who did not attend classes due to flooding lost contact with the content and sequence of the course, causing them to lose time. The group with the virtual class did not lose the course sequence, and

since they continued to interact with their course, they had constant test scores during the semester with days of flooding.

Another factor that enhanced the average test score was the interactivity provided by the virtual class. The virtual labs and simulators stimulated the students' interest by allowing for dynamic interaction, an important variable for the construction of knowledge (ZABEL; GROPENGIESSER, 2011). For example, the students could modify ecosystem variables, e.g. precipitation and temperature values, and observe the resulting survival of animal and plant species. This use of dynamic interactions, events and scenarios is important for the formation of cognition and knowledge (SPIEGEL et al., 2008).

Teachers can use learning management and virtual learning systems to record the performance of their students in terms of many variables, such as presence in the class, test scores, abilities, interactions, and communication, in order to evaluate the processes of teaching and learning (YIP, 2004). The integration of virtual and face-to-face activities is an ideal way to improve student focus on the content of course. The students interact physically with other students, teachers and the face-to-face university, and learning is enhanced by virtual contact in addition to formal classes (CRUMP et al., 2000). The use of distance education alone in biology undergraduate courses have been amply discussed and is possible (ZION et al. 2011). On the other hand, face-to-face and traditional education in biology undergraduate courses, such as field and lab classes, is indispensable for the construction of knowledge (WASMANN-FRAHM, 2009).

Conclusion

The results of this study suggest that the integration of virtual and face-to-face classes will improve the education in Brazil by resolving the mobility problems students experience in going to university on days with flooding. The use of virtual learning objects in the experimental group resulted in satisfactory outcomes because the students' test scores did not decrease during periods of extreme climatic events. The results of this study demonstrate that the group of students with the VLE in addition to face-to-face classes had higher test scores than the group of students without the VLE during semesters with days with flooding. This work proposes that Brazilian education can be improved by: i) improving the drainage of roads and streets to flux off rainwater and ii) investing in a mixed education system with both virtual and face-

to-face learning environments for all biology undergraduate courses.

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