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Advances in Geosciences

Applications of "Integrated Data Viewer" (IDV) in the classroom

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Abstract. Conventionally, weather products utilized in synoptic meteorology reduce phenomena occurring in four dimensions to a 2-dimensional form. This constitutes a road-block for non-atmospheric-science majors who need to take meteorology as a non-mathematical and complementary course to their major programs. This research examines the use of Integrated Data Viewer-IDV as a teaching tool, as it allows a 4-dimensional representation of weather products. IDV was tested in the teaching of synoptic meteorology, weather analysis, and weather map interpretation to non-science students in the laboratory sessions of an introductory meteorology class at Western Michigan University. Comparison of student exam scores according to the laboratory teaching techniques, i.e., traditional lab manual and IDV was performed for short- and long-term learning. Results of the statistical analysis show that the Fall 2004 students in the IDV-based lab session retained learning. However, in the Spring 2005 the exam scores did not reflect retention in learning when compared with IDV-based and MANUAL-based lab scores (short term learning, i.e., exam taken one week after the lab exercise). Testing the long-term learning, seven weeks between the two exams in the Spring 2005, show no statistically significant difference between IDV-based group scores and MANUAL-based group scores. However, the IDV group obtained exam score average slightly higher than the MANUAL group. Statistical testing of the principal hypothesis in this study, leads to the conclusion that the IDV-based method did not prove to be a better teaching tool than the traditional paper-based method. Future studies could potentially find significant differences in the effectiveness of both manual and IDV methods if the conditions had been more controlled. That is, students in the control group should not be exposed to the weather analysis using IDV during lecture.

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1 Introduction

Conventional weather products utilized in the teaching of synoptic meteorology reduce three-dimensional time-dependent phenomena to two-dimensional form. This represents a challenge to the visualization of the spatial and temporal distribution of the atmospheric conditions, especially for non-science majors. Efforts have been made to create interactive learning using the personal computer, (e.g. Whittaker et al., 2002, and Carbone et al., 2005) leading to development of interactive exercises using web-based graphics with Java. Synoptic meteorology requires software for acquisition, processing, analysis and visualization of meteorological data and products. However, this group of software is usually UNIX, or C++ based and requires advanced knowledge of computer sciences, a roadblock for non-atmospheric-science majors who are required to take meteorology as a non-mathematical and complementary course to their programs (Nogueira and Cutrim, 2005). Recently, the three-dimensional integration of meteorological data was made possible through efforts of the University Corporation for Atmospheric Research's Unidata Program Center software, Integrated Data Viewer (IDV). Developed in JAVA, IDV is platform independent and allows real-time data acquisition and visualization of data in the areas of geosciences.

Since the advent of the personal computer technology, faculty, researchers and computer technicians have been continuously working to develop new ways to facilitate understanding of meteorological concepts and visualization of weather phenomena (Ehrmann, 1977, and Ramamurthy et al., 1992). Efforts to improve the teaching of meteorology with IDV technology have been tested at Western Michigan University in the Geography Department. For five consecutives semester, new techniques in teaching meteorology were incorporated in an introductory meteorology class entitled Weather and Climate (Cutrim et al., 2004).

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2 Review literature

Weather phenomena affect our daily life, and for many centuries it has been observed and registered. The first technology used to benefit meteorology was the electric telegraph in 1846, helping to disseminate weather observations in Europe (Monmonier, 1999). In 1942, the computer was introduced in weather forecasting. On 1 April 1960, the first sun-synchronous weather satellite TIROS I was launched. Placed in a nearly circular orbit, 450 miles above the earth, the satellite carried two miniature black-and-white TV cameras designed for mapping cloud cover. Another relevant improvement came out with the RADAR and numerical weather prediction incorporated into the analysis and the forecast (NASA, 2005). New technologies in weather visualization and real-time data distribution through the Internet greatly facilitate education and research in meteorology. However, how do instructors bring this new technology into the classroom and use it to improve teaching and student learning?

Currently, more and more labs and classrooms are equipped with powerful computers and new methodologies in teaching have been developed. Several studies comparing paper-based with computer-based have been published with no conclusive results (Clariana and Wallace, 2002; MacCann et al., 2002; Noyes et al., 2004, and Thirunarayanan and Perez-Prado, 2001). A new approach in teaching meteorology for non-science majors was developed by Whittaker and Ackerman (2002) using applets coded in Java. Interactive exercises and weather parameter visualization in 3-D bring into the classroom a new concept to increase the students' interest in learning. Improving the exercises approach might lead to the real differences between computer-based and paper-based methodology.

Assessments are used to help teachers collect feedback about how well their students are learning in the classroom and labs with new technologies. Student assessment can be applied to quizzes, tests, homework, and surveys. Angelo and Cross (1993) have developed seven assumptions on their model of Classroom Assessment. This research is based on the use of Integrated Data Viewer (IDV) as a teaching tool. IDV is the most recent software created by Unidata: "IDV brings together the ability to display and work with satellite imagery, gridded data (for example, numerical weather prediction model output), surface observations, balloon soundings, NWS WSR-88D Level II and Level III RADAR data, and NOAA National Profiler Network data, all within a unified interface. It also provides 3-D views of the earth system and allows users to interactively slice, dice, and probe the data, creating cross-sections, profiles, animations and value read-outs of multi-dimensional data sets".

3 Procedures

During the two-semester study period, a total of 116 students enrolled in GEOG225. In each semester there were four lab sessions taught by two different instructors. Students were split in those labs by last name and enrolment date. For selected topics, each TA applied this experiment in two lab sessions: one using IDV and another, the control group with the same topic, using the traditional exercise book. . The chapter selected was "Weather Map Analysis" in the exercise book Weather and Climate, Carbone (2004, p. 95–110), covering topics from station models to frontal systems. Each TA graded their lab exercises.

To assess the IDV-based and paper-based lab learning, ten multiple choice questions were incorporated into the next exam. The first two questions covered temperature advection and air mass. An 850-hPa map with isotherm and wind speed and direction was given to the students to be analyzed. The next two questions were about a 500-hPa map, with geopotential heights and winds. Questions 85 to 88 covered the station model subject. The last two questions were about surface sea level pressure and frontal systems. A multiple choice posttest was conducted 47 days after to assess short-term learning, by including four questions in exam #3. Those questions covered the following four topics: temperature advection, surface map, station model, 500 hPa geo-potential heights. In order to have the same number of students in the lab experiment and exams, subjects who did not participate in one of these activities, exam or lab, were excluded from the analysis.

4 Data processing

Student scores from labs and exams were entered and stored into a Microsoft Excel (2002) spreadsheet. The data was analyzed semester by semester, for each of the teaching approaches, i.e., teaching with IDV or with the traditional Lab Manual, for each of the lab sessions. In order to avoid bias by the author, one IDV group and one control group were taught by a Teaching Assistant without previous knowledge of meteorology and with a basic familiarity in IDV. Graphics and descriptive statistics were performed with the Microsoft Excel built-in statistical package. Further statistical analyses were conducted using SPSS for Windows (SPSS 11.0). These SPSS-based analyses included: a) independent-samples t-test to examine if there was a bias inflicted by the lab instructor-TA (not shown); b) independent-samples t-test to examine if there was a difference between teaching approaches in exam scores (not shown), and c) paired sample test for lab/exam comparison for each method. The analyses were performed to answer the principal research question: Did significant differences exist between the group that used the IDV-based exercise and the control group that used the traditional paper-based exercises?

Table 1. SPSS output comparing students’ exam scores.

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
EX_04	Equal variances assumed	.655	.423	-.111	41	.912	-.08	.711	-1.514	1.357
	Equal variances not assumed			-.106	23.141	.916	-.08	.743	-1.615	1.457

Table 2. Spring 2005, paired t-test.

Paired Samples Test

	Paired Differences					t	df	Sig. (2-tailed)
				95% Confidence Interval of the Difference				
	Mean	Std. Deviation	Std. Error Mean	Lower	Upper			
Pair 1 LAB_05 - EX_0	1.821	1.9534	.2387	1.344	2.297	7.630	66	.000

5 Results

Comparison of student exam scores according to the laboratory teaching technique is presented below for each of the semesters of the study period. Additionally, results from student long-term learning analysis are discussed for the Spring 2005 semester.

5.1 Fall 2004 MANUAL versus IDV-based comparison

The semester of Fall 2004 was the first time IDV was compared with a paper-based exercise. Fifty-four students enrolled this semester, but only forty-three (80%) participated in the experiment, both the lab and the exam. The group was composed of thirty-five males and eight females, of which twenty-nine worked with IDV in the lab and fourteen worked with the paper-based exercise. From the total students 58% (25) were Aviation majors, and 42% (18) had majors in Geography, Biology, and other disciplines.

A t-test was run to evaluate if the exam scores showed significant difference between exam scores of students who learned with IDV and those who learned with the MANUAL. Table 1 shows the results, and at a 95% confidence level and based on the F-test$>$0.05 we can assume the samples have equal variance. The p-value of 0.912$>$0.05 indicated that there was no statistically significant difference between the two student groups. However, students in the IDV group have an exam score average slightly higher when compared with student scores in the MANUAL group (IDV=6.79; MANUAL=6.71).

5.2 Spring 2005 MANUAL versus IDV-based comparison

During this semester the number of the students enrolled increased by 46% in relation to the previous semester. From a total of seventy-nine students, only sixty-seven (85%) participated in the lab sections and the exam. The spring 2005 class was composed of fifty-seven male (85%) and ten female students (15%), the majority being Aviation majors (78%), and the remainder 22% from a variety of majors, such as Geography and Psychology.

As in the Fall 2004 semester, the overall lab score average (8.89) was higher than the overall exam score average (7.07), indicating that the students performed better in the lab. That result is confirmed by the t-test with 95% confidence interval, 66 degrees of freedom, and $t_{\text{critical}}=\pm 1.671$ was used. The SPSS 11.0 output is shown in Table 2. The t-value is $7.630 > t_{\text{critical}}$, therefore the results for the paired sample for two tailed t-test reject the null hypothesis: there is difference between lab and exam score average. The next test compared exam scores for each teaching technique. The null hypothesis is that there is no difference in exam scores by groups. The alternative hypothesis is that there is a difference in exam scores by group. Table 4 shows that, at a 95% of confidence and F-test $>$0.05, equal variances can be assumed. The results show a p-value$>$0.05, and we accepted the null hypothesis: there is no difference in exam scores by groups. That means that the IDV group had the same performance as that of the MANUAL group. However, students in the IDV-based group showed a slightly higher average (7.111) compared with the MANUAL-based group average (7.032).

Table 3. SPSS output for exam #3 in Fall 2005 semester.

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
EXAME3	Equal variances assumed	2.849	.096	1.058	65	.294	.0419	.03958	-.03717	.12095
	Equal variances not assumed			1.034	53.813	.306	.0419	.04053	-.03938	.12316

Table 4. SPSS output results for exam #3 in Spring 2005.

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
EX_05	Equal variances assumed	1.644	.204	.180	65	.858	.079	.4389	-.7976	.9553
	Equal variances not assumed			.177	57.408	.860	.079	.4461	-.8143	.9720

5.3 Spring 2005 long term learning analysis

During the Spring 2005 semester the author had an opportunity to measure long-term learning. In exam #3 four extra questions covered the four topics analyzed in this experiment and described in Sect. 4 (Station model, Frontal systems, Temperature advection/air masses, 500 hPa geopotential heights isolines). First, the total scores of the IDV group were compared with the total scores of the MANUAL group using a one-tailed independent t-test at a 95% of confidence level. Table 3 shows p-value$>$0.1, resulting in acceptance of the null hypothesis: there is no difference between groups (IDV and MANUAL) in exam #3. However, the IDV group shows a slightly higher mean value (0.8403) compared with the MANUAL group average (0.7984).

6 Conclusions

The influence of the IDV-based versus the MANUAL–based methods, as reflected on the exam performance, laboratory scores were compared with exam scores on the same subject. Results of the statistical analysis show that the Fall 2004 students in the IDV-based lab session retained learning. However, in the Spring 2005 the exam scores did not reflect retention in learning when compared with IDV-based and MANUAL-based lab scores (short term learning, i.e., exam taken one week after the lab exercise).

Comparison of the average exam scores in Fall 2004 and Spring 2005 between students in the IDV-based session and in the MANUAL-based lab session shows that there is no statistically significant difference between the two student groups. Both groups have equivalent scores in the exam questions related to the laboratory exercises. However, the IDV-based group showed a slightly higher exam score average comparing to the MANUAL-based group in 2004 and 2005.

Testing the long-term learning, seven weeks between the two exams in the Spring 2005, shows no statistically significant difference between IDV-based group scores and MANUAL-based group scores. However, the IDV group obtained exam score average slightly higher than the MANUAL group. Statistical testing of the principal hypothesis, leads to the conclusion that the IDV-based method did not prove to be a better teaching tool than the traditional paper-based method.

In conclusion, this research shows that the use of IDV as a teaching tool is comparable with the conventional lab manual. Meteorology labs using IDV might improve student interest in learning how the atmosphere works by comparing the weather computer models, station models, satellite images and radars with what the students are seeing through the lab windows. Future IDV versions with improved teaching features could lead to the formulation of better laboratory exercises.

The lack of statistical support favoring the IDV method was disappointing given that anecdotally, students seemed more engaged and contributed more thoughtful comments and questions during the weather analysis discussion after

IDV was introduced. Future studies could potentially find significant differences in the effectiveness of both manual and IDV methods if the conditions had been more controlled. That is, students in the control group should not be exposed to the IDV during lecture.

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