VISSER: Addressing the need for modern science laboratories in the Philippines

John Raymond Pingol, University of the Philippines Diliman, Philippines
Ranzivelle Marianne Roxas-Villanueva, University of the Philippines Diliman, Philippines
Giovanni Tapang, University of the Philippines Diliman, Philippines

The Asian Conference on Education & International Development 2015
Official Conference proceedings

Abstract
Access to modern science laboratories is still a problem in most public high schools in developing countries like the Philippines. Based on a survey with 173 respondents conducted from September 2013 to June 2014, 77% of schools have laboratories. However, only 33% and 15% have access to digital measuring devices and sensors, respectively. To address the need for modern science laboratories, we develop the Versatile Instrumentation System for Science Education and Research (VISSER). VISSER integrates both hardware and software in the experiments and research. It uses both generic and custom probes that can be adapted for different applications. Handheld modules and sensors were developed to be compact and can be used without a computer. These modules are currently being piloted in-class in the subject areas of physics, chemistry, biology, environmental science and engineering. Despite its sophistication, VISSER is cost-effective. The modules are roughly 1/10th of currently available commercial products which makes it affordable to all schools, even to those that have extremely modest funding.

Keywords: science education, instrumentation, hands-on learning

Introduction

Science is best taught by experiential learning through the use of hands-on activities. Students who are engaged in hands-on activities attained higher science achievement scores compared to those who not (Stohr-Hunt, 1998). Better learning and attitude towards science are also developed when students experience actual science through hands-on activities integrated in classrooms (Carlson, L.E. and Sullivan, J.F.,1999, Onstein, A., 2006). Pedagogical measures show improvement in learning when modern technologies where incorporated in teaching (Zacharia, Z. and Constatinou, C. 2008). Modern technology, such as modern instrumentation can definitely improve learning through hands-on activities (Roxas-Villanueva, RM et al., 2012).

The Philippines struggled to improve the quality of its science education. In the 2011-2012 Global Competitiveness Report of the World Economic Forum, the Philippines ranked 112th out of 139 in 2011, and 115th out of 142 in 2012 in quality of math and science education. This is the Philippines' rank even though 1100 minutes per week is spent on science by every student under its basic education curriculum, higher than neighboring countries Brunei (810 min/week), Singapore (540 min/week), and Malaysia (360 min/week). Education spending in the Philippines, at $138/student/year is more in line with its science and mathematics performance since it is lower than Thailand ($853/student/year) and Singapore ($1,800/student/year) (World Economic Forum, 2011). Apparent problems with Philippines' science education are the lack of laboratory facilities and equipment, and modern instrumentation. This limits the capacity of teachers to guide students learning through experimentation and hands-on activities.

A survey participated by 173 teachers from different provinces in the Philippines shows that there are still 23% that do not have access to a laboratory and only 39% have access to at least one laboratory dedicated to a specific field of science (Figure 1). Modern instrumentation, such as measuring sensors are only limited to 15% of the respondents (Figure 2).

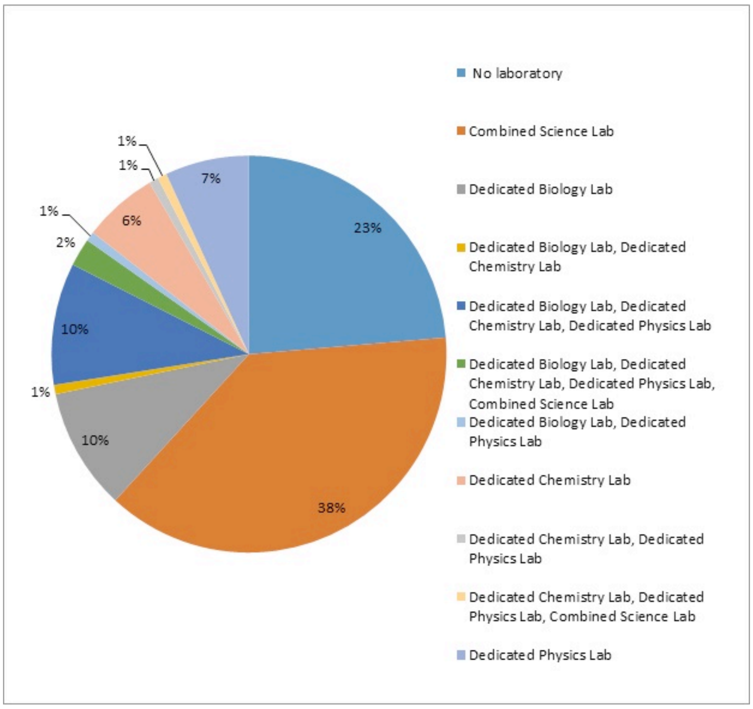
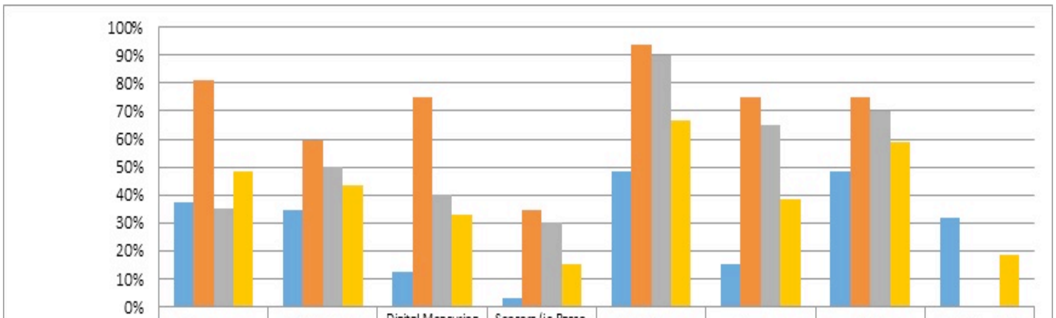


Figure 1: Teachers’ access to a laboratory facility



	Computers	DVD/VCR/VHS	Digital Measuring Device	Sensors (ie.Pasco, Vernier)	LCD Projector	Internet	TV	No MT Available
Public Schools	38%	35%	13%	3%	49%	15%	49%	32%
Science High Schools	81%	59%	75%	34%	94%	75%	75%	0%
Private Schools	35%	50%	40%	30%	90%	65%	70%	0%
Total	48%	44%	33%	15%	67%	39%	59%	19%

Figure 1: Teachers’ access to modern technology

VISSER aims to provide high schools with a stronger backbone on science subjects, through the establishment of a system centered on a handheld microcontroller-based universal platform used in a network of different sensors to perform experiments in various science fields and production of fully integrated hardware and software that are supplemented by well-written, highly descriptive experimental modules.

Methodology

The integration of handheld and sensors, and experimental modules enable VISSER to develop different experimental set-ups in the field of physics, chemistry, biology, environmental science and engineering that can be used in science laboratories in different Philippine-school settings.

The Handheld is based on a programmable microcontroller with 8 ports where sensors can be attached. Users with skills in programming can alter and improve experimental set-up or even design its own. Different sensors can be simultaneously used to develop diverse set-ups.

Acquisition of data can be done real-time and can be also saved in a SD card if computers are not readily available for data processing. The handheld can be powered through USB, power outlet or batteries that considers the availability of resources in any school setting. It can be also use in field experiments outside the confines of the laboratory. Visualization is readily available when attached into a computer. Illustrating relationships through graphs and trends are effortless since data is rapidly collected digitally.

Home-grown experimental modules reflect the local experiences and include specific and measurable objectives that would guide educators in its use. Higher Order Thinking Skills (HOTS) were consciously placed in the objectives so that students will develop deeper knowledge in the topics and skills that are necessary for the changing times. The experimental modules use inquiry-based approach in presenting the topic. The modules are design to include in its parts the 5 E's (Engage, Explore, Explain, Elaborate and Evaluate/Extend) of the inquiry-based approach to seamlessly tackle lessons in different fields of science and engineering.

Despite its sophistication, VISSER is cost-effective. The modules are roughly $1/10^{th}$ of currently available commercial products which makes it affordable to all schools, even to those that have extremely modest funding.

VISSER is tested in real classroom set-up through the use of two teaching methods, hands-on experiment and teaching demonstration. For hands-on experiment, or simply Hands-on, students, divided in groups of 3 or 4, performed the experiments following the VISSER modules with teachers acting as facilitators. After the experiments, the teachers conducted a post laboratory discussion. For the second method, the teacher would teach the same module in his or her preferred teaching technique but must incorporate a teaching demonstration of the experiment described in the VISSER module, the method is called Demo. The content, objectives and time duration was kept constant for both teaching method. A control was set by randomly selecting student that would have an unguided reading activity (Reading) of the same topic.

Both teaching methods and control took an examination before and after the conduct of the testing. The preliminary and post examination have the same number of items and level of difficulty. The comparison of result in preliminary and post exam would indicate the immediate cognitive learning impact of VISSER to students.

The preliminary and post test scores where compared using the Hake gain (Hake, R. R.., 1998). The Hake gain or the average normalized gain <g> can be computed by taking the ratio of the actual average gain <G> to the maximum possible average gain (Hake, R. R.., 1998), i.e.,

$$< g > = \frac{\% < G >}{\% < G >_{max}} = \frac{\% < S_f > - \% < S_i >}{100\% - \% < S_i >}$$

where %<S_i> is the percent average of the preliminary test scores and %<S_f> is the percent average of post test scores. The range of the Hake gain is between -1 and 1. A positive <g> indicates that students perform better in the post test compared to the preliminary test, and <g> = 0 means students' performance is the same. A higher <g>suggests higher cognitive learning of students. A negative value for <g> indicated that instead of cognitive learning, misconceptions or confusions were developed.

The Hake gain of students can be classified by the following: <g> ≥ 0.7, High Hake gain; 0.3≤ <g> < 0.7, Medium Hake gain; and <g> < 0.3, Low Hake gain (Hake, R. R.., 1998).

Results and Discussion

Figure 3 plots the %<G> vs S_i of 173 students from 4 heterogeneous sections of the same grade-level (grade 9) that participated in the "in class testing" of the VISSER Charles' Law modules. The three solid lines mark the boundary between Hake gain classifications.

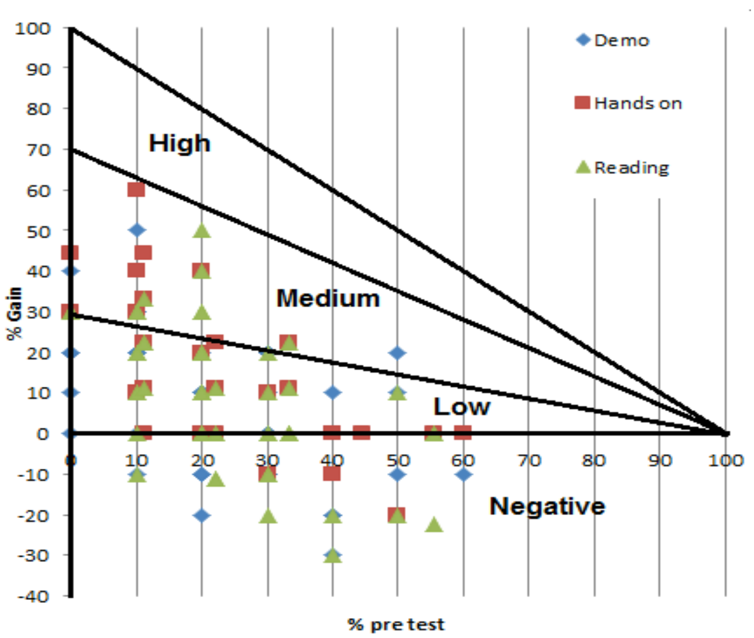


Figure 3: %<G>vs S_i of students in 3 groups. Blue for Demo, red for Hands-on and green for Reading

No student attained High Hake gain on the three experimental groups. Students fall between medium and low gain regime, 60% for Demo,70% for Hands-on and 73% for Reading. This means that the maximum cognitive learning was not attained using any of the two methods used. Mastery of the topic is not yet developed, since the post exam was given right after the learning activity. But giving the post exam straightaway approximates the impact of each method in the cognitive learning of students.

In Table 1, we can observe that majority of the students in each group have a positive Hake gain. This indicates that majority of the students' attained cognitive learning regardless of teaching methods used. Twenty-five percent of students in Hands-on achieved Medium Hake gain, this is higher compared to the other two teaching method. Students in the Hands-on group also attained the highest average Hake gain (0.19).

Table 1: Summary of results

	Demo		**Hands on**		**Reading**	
Frequency	48		67		58	
High Hake gain	0	0%	0	0%	0	0%
Medium Hake gain	5	10%	17	25%	11	20%
Low Hake gain	30	50%	40	45%	37	53%
Hake gain = 0	6	13%	10	15%	6	10%
Negative Hake gain	13	27%	10	15%	10	17%
Average % Gain	7.29%		14.86%		8.95%	
Average Hake gain	0.09		0.19		0.12	
Standard Deviation	0.22		0.23		0.23	

Negative gain is present regardless of what group they belong; misconceptions or confusions can be developed in the methods used in the testing. The biggest percentage of students that have negative Hake gain belongs to the Demo group while the lowest belongs to the Hands on group.

Developing misconception or confusion can be attributed to the roles of teachers in the learning process. In the group conducting hands on experiment, the students are directly experiencing the phenomena. Student learning are guided by the VISSER module with facilitation of the teachers. Students' direct participation in the learning activity promotes self –learning and conception of his own knowledge. The facilitation of teachers results in lower percentage of students who have developed misconception as compared to reading activity wherein they are unguided and allowed to read at their own pace.

A large, but consistent standard deviation is computed on the Hake gain of the three groups. This shows how students vary randomly in characteristics, such as how they understand the concepts, their prior abilities and attitudes towards the exam. [8].

Conclusion

The lack of facilities and modern instrumentation in secondary schools limits the capacity of teachers to implement experiential learning through hands-on activities. VISSER address this deficiency by providing microcontroller-based handheld, coupled with sensors and set-up and guided by modules developed for Philippine schools in the field of biology, chemistry, physics, environmental science and engineering. Hands-on experimentation using VISSER resulted in a positive net Hake gain. It also comparatively resulted into smaller negative Hake gain due to mistakes or confusion.

Still, negative Hake gain should be addressed. This could be done by making revisions to the VISSER modules. Adaptation to the K-12 curriculum is being implemented. The “in-class testing” must be replicated to more schools in different school conditions in the Philippines. Aside from cognitive learning, affective and skills learning will also be incorporated.

References

Stohr-Hunt, P.M. (1998). “An analysis of frequency of hands-on experience and science achievement”, *Journal of Research in Science Teaching,* **33**, pp 101-109,.

Carlson, L.E. and Sullivan, J.F. (1999). “Hands-on Engineering: Learning by Doing in the Integrated Teaching and Learning Program”, *Int. J. Engng. Ed.,* **15**(1), pp. 20-31.

Onstein, A. (2006) “The Frequency of Hands-On Experimentation and Student Attitudes towards Science: A Statistically Significant Relation”, *J. of Science Education and Technology*, 15, pp 285-297, DOI:10.007/s10956-006-9015-5

Zacharia, Z. and Constatinou, C. (2008).“Comparing the influence of physical and virtual manipulatives in the context of the Physics by Inquiry curriculum: The case of undergraduate students’ conceptual understanding of heat and temperature”. *Am. J. Phy.* 76 (4 & 5).425-430.

Roxas-Villanueva, RM et al. (2012). “VISSER: Enhancing Science education through hands-on experiment”, Proc. of 30Th Samahang Pisikang Pilipino Congress, DLSHSI, Cavite, Philippines

World Economic Forum (2011). 2011-2012 Global Competitiveness Report, Geneva, Switzerland.

Hake, R. R.. (1998).“Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory course”, *Am J. Phy.*66, 1, 65-74, 1998

Contact email: rmlroxas@gmail.com, jppingol1@up.edu.ph