Title

AN OUTCOME-BASED FRAMEWORK FOR TECHNOLOGY INTEGRATION IN HIGHER EDUCATION STATISTICS CURRICULA FOR NON-MAJORS

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1. INTRODUCTION

In this Age of Information characterized by rapid advances in technological innovations, the increased availability of computers and access to the Internet have tremendously changed the landscape of statistics education worldwide. Technology-based teaching and learning tools such as educational software, statistical packages, applets, videos, course management and personal response systems, and other dynamic and interactive learning resources in the World Wide Web have expanded the statistical knowledge-base and range of competencies that are expected outcomes of statistics education. Global reform efforts that optimize technology use in all levels of teaching statistics and the role of technology in teaching and learning statistics have dominated discussions in many professional statistics conferences (for example, the 1996 and 2012 IASE Roundtable Conferences) and in statistics education research literature (for example, Glencross & Binyavanga, 1996; Chance, Ben-Zvi, Garfield and Medina, 2007).

From an international perspective, technology has pervaded almost all facets of teaching and learning statistics. Moreover, the reality of statistics education in the Philippines shows that we have not coped adequately with technology integration and many classes are similar to those offered 10 or 20 years ago. *"Why have we fallen so far behind*?" Former president of the Philippine Statistical Association (PSA), Dr. Isidoro David, raised this question and presented some answers from both macro and micro perspectives in a paper presented to the Commission on Higher Education (CHED) in 2010. The teaching of introductory college statistics is plagued with many problems, including lack of teacher preparation and quality textbooks and the dominance of traditional formula-based teaching approaches with little or no student engagement and technology integration (Reston, Jala, & Edullantes, 2006). A review of locally authored introductory statistics textbooks by the PSA revealed that most of these textbooks were written by non-statisticians, did not encourage or require the use of computers, and that "statistical reasoning and logic was largely amateurish, with statistical methods enumerated like recipes in a cookbook" (David and Maligalig, 2006, p. 5).

The case of statistics education in the Philippines is a reality shared by many developing countries. Moreover, recent education reforms such as *K to 12 Basic Education* program (Department of Education, 2012), the Revised General Education Program in tertiary level and the introduction of Outcome-Based Education (Commission on Higher Education, 2012) have provided the opportunity for statistics education to assert its important role toward improved higher education outcomes. Since mathematics and statistics are part of the core subject area in the Revised General Education curriculum at the tertiary level, there is need for vertical articulation in the goals, methods and outcomes of teaching of statistics for non-majors as students move from undergraduate to graduate statistics courses. However, the challenge of reform toward outcome-based education requires some framework upon which to articulate the desired outcomes in the different levels of teaching statistics in higher education. In particular, this paper focuses on statistics education for non-specialists of the field, that is, for non-statistics majors. Aside from the introductory college statistics for undergraduates, most graduate programs offer at least a three-unit course in statistics at the Master's and at the doctorate level. Currently, these courses are treated independently with no framework for organization to facilitate the transition from undergraduate to graduate-level statistics. Thus, this theoretical paper aims to address this need through an outcome-based organizing framework for technology integration in course design and teaching practice in higher education statistics.

Toward these ends, this paper seeks to address the following questions:

1. What organizing framework for technology integration in higher education statistics curricula may be designed to reflect *clarity of focus on culminating outcomes of significance* within undergraduate and graduate statistics courses for non-majors?
2. In the face of limited resources in most Philippine higher education institutions (HEIs), what available technologies can be used to provide *expanded opportunities* for successful learning of statistics among non-statistics majors from undergraduate to graduate levels of higher education?
3. What is the role of technology in *backwards design* of students' learning experiences through course activities that target *high expectations for all students* to succeed in terms of attainment of significant learning outcomes in relation to the goals of statistics instruction at the undergraduate, Master's and doctorate level?

Today, many reform efforts across different levels of statistics education in many countries have explored the vital role of technology in improving the desired outcomes of statistics instruction. The outcome-based framework presented in this paper may be useful to statistics educators and curriculum developers from other countries as well as serving as a guide for course design in order to provide continuity and coherence, and reduce redundancy in both content and learning experiences as students move from undergraduate to graduate-level statistics.

2. THEORETICAL BACKGROUND

Curriculum reforms need to be anchored on sound educational theory and pedagogical principles. The theoretical underpinnings of this paper are drawn from the principles of Outcome-based Education (OBE) which may be viewed in three different ways—as a theory of education, as a systemic structure for education, or as classroom practice (Killen, 2000). In particular, this paper is anchored on OBE as a student-centered approach to education that focuses on intended learning outcomes resulting from instruction (Nicholson, 2011) and as a process that involves the restructuring of curriculum, assessment and reporting practices in education to reflect the achievement of high order learning and mastery (Tucker, 2004). The four essential principles of OBE that guide the proposed framework for technology integration as articulated in the first research question are as follows: (1) *clarity of focus on culminating outcomes of significance;* (2) *expanded opportunity and support for learning success*; *(3) high expectations for all to succeed*; and (4) *designing down from your ultimate culminating outcomes*. Further, this paper adheres to the ideas of *transformational OBE* which focuses on high quality outcomes in which students demonstrate significant learning in context and which emphasizes long-term, cross-curricular outcomes that are related directly to students' future life roles in society (Spady, 1994; cited in Killen, 2000).

In teaching statistics, the role of technology in the design of the appropriate learning activities can substantially expand the opportunities for students to achieve significant learning outcomes. Moore (1997) argued that the case for reform in statistics instruction is built on strong synergies between *content, pedagogy,* and *technology*. He claimed that the most effective learning takes place when content, pedagogy, and technology reinforce each other in a balanced manner. Statistics education literature is replete with resources on technology integration in course design for statistics classes (see for example: Kaplan, 2011; Mills & Raju, 2011; Harraway, 2012).

From the perspective of curriculum implementation and teaching practice, the *Gradual Release of Responsibility (GRR) Model* developed by Pearson and Gallagher in 1983 (cited in Fisher, 2006) provides a motivation for classifying levels of technology integration in different levels of statistics teaching. The GRR model, as shown in Figure 1, is a research-based optimal learning model which stipulates that the responsibility for task completion shifts gradually over time from the teacher to the student, and from modeled, shared and then guided instruction to independent learning; that is, from teacher ownership to student ownership of learning. The model has four interrelated components; namely: (1) focused lessons, (2) guided instruction, (3) collaborative learning, and (4) independent learning (Fisher, 2006). This model is not linear; that is, students may move back and forth among each component as they master skills, strategies and learning standards of a particular course.

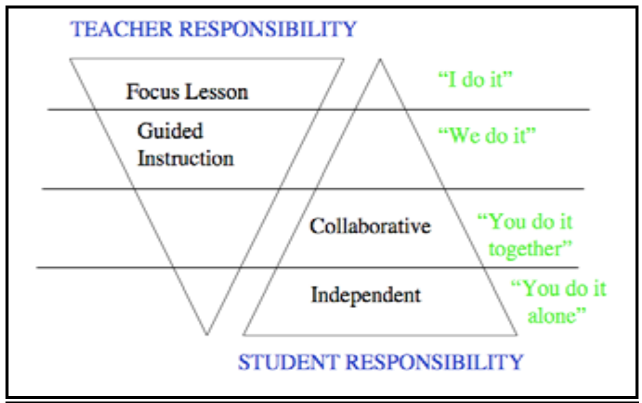

Figure 1: The Gradual Release of Responsibility Model
(Pearson and Gallagher 1993, cited in Fisher, 2006)

On the other hand, Taggart's (2005) Reflective Thinking Model provides the motivation for organizing content and learning experiences with differing levels of technology use from the teacher's perspective. This model provides a hierarchical framework involving three levels: (1) the *technical level* where focus is on teacher competency towards meeting outcomes in relation to course content, behaviours and skills with reference to students' past experiences; (2) the *contextual level* where focus is on relating content to context and student needs and the consideration of alternative practices; and (3) the dialectical model which focused on disciplined inquiry, individual autonomy and self-understanding, and consideration of moral, ethical and socio-political issues.

In teaching statistics with technology, reflective practice may be viewed as a way to move out of the rut of automation and routine technology applications in order for teachers to achieve a higher level of awareness on the kinds of decisions they make as they teach with technology and of the value and consequences of particular instructional decisions. Porter (2001), for instance, recounted a case study on improving statistics education through reflective practice. With the aim of unpacking the statistical expertise of the teacher in order to improve statistics teaching and learning, Porter presented a series of case studies of statistics classes as part of the Gateway Program at an Australian University. One case study entitled *Revising the Literacy curriculum* illustrated activity-based teaching that used various resources including the use of video clips and web-based technology to facilitate students' learning of statistical concepts. In particular, students were introduced to the *Decisions through Data* videos which were used as both to enrich and establish the relevance of statistics to the disciplines and to everyday life. An examination of the teacher reflections led to a change in the curriculum for the second implementation and improved student participation. Through this reflective process, the author described how reflective practice evolved as a methodology that directed changes in the classroom which led to improved teaching practice and student learning.

While the use of technology to facilitate and improve the learning of statistical concepts is well-supported by research, effective utilization of technology requires thoughtful and deliberate planning, as well as creativity and enthusiasm, and the need for a system to critically evaluate existing software from the perspective of educating students (Chance, Ben-Zvi, Garfield, & Medina, 2007).

3. DISCUSSION AND IMPLICATIONS

This section presents some discussion from reviewing prior work in answer to the problems put forth at the beginning of this paper. In line with the research questions presented earlier, the organization of the discussion proceeds from the local Philippine context to a global perspective on statistics education. The first section combines ideas of Pearson and Gallagher's Gradual Release of Responsibility Model (Porter, 2006) and Taggarts's (2005) Model of Reflective Thinking in developing a framework for organizing learning experiences that provide *expanded learning opportunities* with technology. The second section presents a categorization of available technologies for *expanded opportunities* for successful learning of statistics and probability and how the framework may be used to guide teacher decisions in the use of these technologies. Finally, the third section provides a mapping of the goals and intended learning outcomes for teaching statistics to illustrate how these outcomes were vertically articulated in the framework as basis for designing learning experiences with technology.

3.1 A Framework for Technology Integration in Statistics Courses

In response to the Philippine higher education reform agenda toward outcome-based education, this section will address the need for a coherent and vertically articulated outcome-based curricula for higher education statistics courses from undergraduate to graduate level. The principles of outcome-based education along with the ideas from Pearson and Gallagher's Gradual Release of Responsibility Model (Porter, 2006) and Taggarts's (2005) Model of Reflective Thinking were combined to provide the framework for organizing the goals of statistics education and expected learning outcomes with increasing levels of sophistication. The resulting outcome-based organizing framework is shown in Figure 2.

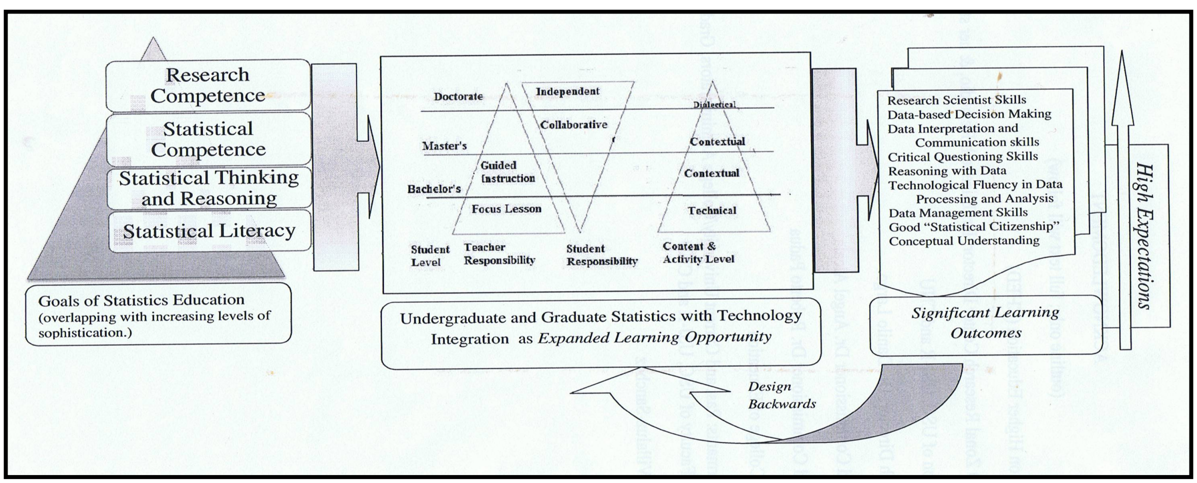

Figure 2. An Outcome-Based Organizing Framework for Technology Integration in Designing Learning Experiences in Statistics Courses for Non-majors

Grounded in the goals of statistics education, Figure 2 shows that these goals are built-up from the most basic to the most complex as the students advance from undergraduate to graduate-level statistics courses. These goals are not necessarily linear and they may overlap within each level of statistics teaching. *Clarity of focus*, as the first principle of OBE, requires that all content materials, learning experiences, including technology engagement as well as assessment, must be aligned with these goals. The focus of teaching and learning activities is the development of essential knowledge, skills and dispositions among students in order for them to ultimately achieve significant outcomes aligned with these goals. The combined ideas of the Gradual Release of Responsibility Model and the Reflective Thinking Model are used in the framework to guide the design of teaching and learning activities to meet these goals. On the other end of the framework are the intended learning outcomes for students, which must be significant to students' lives and society and must meet high standards or expectations for success. A clear definition of what comprise *significant learning outcomes* that students must achieve by the end of their statistics education provides the starting point for curriculum design in OBE. Another principle in OBE, *designing backwards*, is applied in the design of learning activities with *extended opportunities* for successful learning primarily driven by technology.

Here the *Gradual Release of Responsibility Model* depicts the gradual release of responsibility for learning from the teacher to the student as students advance in their statistics education from baccalaureate to Master's and then to doctorate programs. Undergraduate teaching, often characterized by a focused lesson, guided instruction and teacher modeling will gradually move towards collaborative modes of learning as the teacher releases the responsibility of learning to the students. The use of different technology resources will facilitate this transition as it provides students with the opportunity beyond classroom time to develop and enhance conceptual and procedural knowledge with minimal or no teacher support. At the graduate level, learning experiences with technology will move from guided instruction to collaborative learning, and then to independent learning with increasing emphasis as students progress through their graduate program. While course management systems may provide the platform for collaborative learning, other technology tools like a course disk may be used *in addition to* course management systems to facilitate the transition to independent learning. A typical course disk, in CD/DVD format, may include the course syllabus, calendar of activities, instructions, handouts, assignments, interactive content such as quizzes and surveys, software, statistical tables, example program files, program code, data files, video lectures and tutorials, and pertinent website links (Perret, 2010).

Concurrently, the Reflective Thinking Model by Taggart (2005) is used in this framework to correspond to the levels of technology integration in the design of statistics courses for non-majors. These levels may be considered as dynamic, moving from technical to contextual and then to dialectical with increasing level of emphasis as the students move from undergraduate to graduate statistics classes. At the technical level, technology integration is more teacher-directed with focus on teacher competency in using various forms of available technology towards meeting intended learning outcomes. At the contextual level, the course design is characterized by collaborative and situational analysis where students evaluate alternative technology products and practices, relate the statistics content to real life contexts and their own professional needs, and use technology for analysis, clarification and validation of statistical methods and principles. At the dialectical level, the teacher designs the statistics curriculum for optimal integration of various forms of emerging technologies in the context of real world problems towards independent learning, individual autonomy and self-understanding through disciplined inquiry and critical evaluation of various perspectives in doing statistics with consideration of ethical and social issues.

This framework could serve as a guide for statistics educators and administrators in designing and implementing statistics curriculum that is more relevant, responsive and transformative in line with students' needs as they take their respective future roles in society. Use of this framework also requires that all educational decisions are made based on how best to facilitate the desired student outcomes. As students move through the levels from introductory college statistics to graduate level, they are expected to be able to do more challenging tasks other than simply recall concepts and procedures through a written test. Thus, assessment expectations must also shift in focus from rote calculations and traditional formula-based statistical problem solving to more authentic forms of assessments in terms of what students do when they become professionals in their respective fields. Students will play various roles as data collectors, data analysts, data producers, data consumers and decision-makers as they, with the aid of technology, encode, organize and analyze data sets, complete projects, give case presentations, show their abilities to think and reason with data, question validity of statistical claims, conduct empirical research, interpret data analysis results from software packages, and make conclusions and decisions based on the findings. Accordingly, tasks, assignments and tests are not merely perceived as means to attest the students' degree of knowledge and competence as basis for grading but also as a way to improve the learning process itself.

3.2 Available Technologies for Expanded Learning Opportunities

To assist in the actualization of the intended technology integration as depicted in the organizing framework presented Figure 2, this section presents a survey of available technologies presented in statistics education literature and their various roles in attaining the goals of statistics education and students' demonstration of intended learning outcomes. Over the past two decades, the role of technology in teaching and learning statistics has been explored extensively in statistics education literature (see for example: Dallal, 1990; Glencross & Binyavanga, 1996; Velleman & Moore, 1996; Chance et al, 2007 ; Callingham, 2011). These roles include, among others, the use of technology as (1) a "representational media" that reduced the computational load; (2) a tool for developing and communicating statistical understanding, (Callingham, 2001); and (3) a tool for assessment of student learning, either to produce work for assessment or as an integral part of the assessment itself (Jolliffe, 1997; Callingham, 2011). In addition, technological tools can bring into the statistics classroom rich real-world problems with statistical applications, provide scaffolds and tools to enhance learning, and give students and teachers more opportunities for feedback, reflection, and revision (Bransford, Brown, & Cocking 2000; cited in Chance et al, 2007).

Technology tools for teaching statistics and probability may be classified into several categories: statistical software packages, educational software, spreadsheets, applets/stand-alone applications, graphing calculators, multimedia materials, course management systems, personal response systems, and data repositories. Statistical software packages, as menu-driven programs designed for the explicit purpose of performing statistical analyses include, among others,

- *Minitab,* http://www.minitab.com
- *Statistical Package for the Social Science (SPSS),* http://www.spss.com
- *Statistical Application Software (SAS)* http://www.sas.com
- *R,* http://www.r-project.org
- *StatCrunch,* http://www.statcrunch.com
- *GenStat* (General Statistics for Teaching and Learning, GTL Schools and GTL Undergraduate) http://www.vsni.co.uk/software/genstat-teaching.

These software packages vary in terms of cost and availability. While *R* and *GenStat* are free, other packages such as SAS, SPSS and Minitab come with a licensing cost. In the Philippine context, statistical software packages and spreadsheets, primarily, *Microsoft Excel,* are often the target when a teacher speaks of technology tools for teaching statistics. This despite the wide range of technology resources available worldwide. Reduced class time for calculations is a major advantage in integrating statistical software.

Statistics education experts suggest some inexpensive or open-source alternative web-based programs for teaching data analysis. *StatCrunch* (www.statcrunch.com) is a fully functional, very inexpensive, Web-based statistical package with an easy-to-use interface and basic statistical routines suited for educational needs (Chance et al, 2007). Harraway (2012) suggests the use of motivational videos, real data and free software in teaching and learning statistics. He also recommended and demonstrated the use of *GenStat*(General Statistics) Sotftware which covers the statistical techniques in the school curriculum and advanced statistical techniques in undergraduate university subjects. The GenStat software is free of charge but is not open-source software (Harraway, 2012).

Aside from statistical software packages, educational software is another category of technology tools that provide expanded opportunities for teaching and learning statistics beginning at school level. These programs have been developed exclusively for helping students learn statistics through building their understanding of abstract concepts and processes in statistics, providing data access, linked representations, animations, and easier annotation of data analyses and presentations. Examples of these programs include:

- *Fathom,* http://www.keypress.com/x5656.xml
- *TinkerPlots,* http://www.keypress.com/x5715.xml
- *InspireData* http://www.inspiration.com/productinfo/inspiredata

Fathom, in particular, provides a dynamic computer learning environment for teaching data analysis and statistics based on dragging, visualization, simulation, and networked collaboration (Chance, et al, 2007). These types of educational software have not reached the majority of Philippine schools, however, except perhaps to a few colleges and universities.

Other types of technological tools used in teaching and learning statistics have been studied in terms of their impact on student learning. Statistics educators and researchers from more developed countries have reported and evaluated the use of graphing calculators and personal response systems like clicker technology. As a learning tool designed to help students visualize and better understand concepts, graphing calculators have been used as computational tool, transformational tool, data collection and analysis tool, visualizing tool, and checking tool (Doerr & Zangor 2000, cited in Chance et al, 2007). On the other hand, clickers have gained popularity in their effectiveness in providing an active learning environment that encourages student participation and for assessing students' understanding in large classes (Kaplan, 2011). For expanding opportunities for success in teaching and learning statistics using available web-based technology resources, a sample of these resources by type is presented in Table 1 along with their features and functions.

3.3 Role of Technology in Designing Students' Learning Experiences

In defining the role of technology in statistics education, there is need to re-examine student learning goals as technology allows changes in instructional focus that must be reflected in the course goals and corresponding student assessments (Chance, et al, 2007). Further, well-defined educational visions, curriculum design, and teacher preparation and support have been identified as key factors for successfully integrating technology in the classroom (Kleiman 2004, cited in Chance, et al, 2007). In this paper, transformational OBE provides a relevant theoretical basis for designing curricula with learning goals that focus on what is essential for all students to be able to do.

Table 1. Some Available Web-based Technology Resources for Expanded Opportunities in Teaching and Learning Statistics

Types	Some Examples	Functions
Applets/ Stand-alone Applications	An extensive collection of applets developed by Rossman and Chance in http://www.rossmanchance.com/applets Monty Hall problem, http://www.shodor.org/interactivate/activities/AdvancedMontyHall Sampling Reese's Pieces http://www.rossmanchance.com/applets/Reeses/ReesesPieces.html *Sampling SIM* http://www.tc.umn.edu/~delma001/stat_tools/software.htm	An applet is a software component that usually performs a narrow function and runs typically in a Web browser. • Help students explore concepts in a visual, interactive and dynamic environment. • Can be freely and easily found on the Web but are not often accompanied by detailed documentation and activities to guide student use.
Multimedia Materials	*ActivStats* , http://www.activstats.com *CyberStats* http://www.cyberk.com .	Used in college classrooms, combining videos of real world uses of statistics, mini-lectures accompanied by animation, links to applet-like tools, and the ability to instantly launch a statistical software package and analyze a data set.
Data Repositories	*The Data and Story Library (DASL)* http://lib.stat.cmu.edu/DASL *Journal of Statistics Education* (JSE) *Dataset and Stories* http://www.amstat.org/publications/jse/jse_data_archive.html	Pedagogically rich data sets and exploratory activities for use with students. DASL, 2011 is an online library of data files and stories that illustrate the use of basic statistics methods.
Journal Publications	*The American Statistician,* http://www.amstat.org/PUBLICATIONS/ *The Journal of Statistical Software* http://www.jstatsoft.org	Regularly provides comprehensive software reviews
Case Study Videos and Movies	http://www.maths.otago.ac.nz/videos/statistics - hosts lesson plans that integrate software with videos and accompanying data.	Provides links to case study videos describing contexts, study designs, data files and lessons using the new software for data exploration and analysis. (Harraway, 2012)
Teacher Resource websites	*Consortium for the Advancement of Undergraduate Statistics Education* (CAUSE), http://www.causeweb.org .	Provides a compendium of statistics teaching and learning resources such as peer-reviewed classroom activities, datasets, applets, video series and other curriculum resource materials.
Course management systems	Blackboard and WebCT http://www.webct.com New Web 2.0 tools such as *Wiki* can facilitate collaborative learning and bring about instructional change to improve student learning of statistics (Ben-Zvi, 2007).	These systems play a large role, both in communication and collaboration capabilities (e.g., on-line discussion boards, video presentations and tutorials, pooling data across students, sharing instantly collected data across institutions), as well as in assessment. It is feasible to administer on-line surveys and quizzes with instant scoring and feedback to the students.

The notion of orienting statistics education to the future needs of students and of society has been the underlying principle of many papers on the goals of statistics education. Gal and Garfield, for instance, contended that the overarching goal of statistics education is that by the time students finish their encounters with statistics, they become *informed citizens* who are able to:

- Comprehend and deal with uncertainty and variability, and statistical information in the world around them, and participate actively in an information–laden society.
- Contribute to or take part in the production, interpretation, and communication of data pertaining to problems they encounter in their professional life. (1997, p.2)

At the college undergraduate level, many statistics educators agree that the foremost goal for teaching introductory statistics courses is the development of *statistical literacy* (Rumsey, 2002; delMas, 2002). Although there is no universally accepted definition of statistical literacy, statistics education research has produced an expanding view of what comprise this construct (see for example: Wallman, 1993; Watson, 1997; Schield, 2002; Watson and Callingham, 2003). Grounded on these goals and desired student outcomes for different levels of statistics courses, the role of technology and some of its essential features are identified. For undergraduate introductory statistics courses, the results are summarized in Table 2A.

Table 2A. Mapping Out Goals of Undergraduate Statistics Education vis-à-vis Intended Learning Outcomes and Role of Technology in the Designing Learning Experiences

Goals	Significant Student Outcomes	Role of Technology
Develop statistical literacy	• Conceptual understanding and appropriate use of statistical terminology • Understanding of statistical language and concepts embedded in the context of social discussion (Watson, 1997) • Data awareness, interpretive skills, sense-making, and communication skills, useful statistical dispositions • Understand statistics well enough to be able to use information responsibly	• Graphical features of software packages, spreadsheets and educational software as representational media for the reproduction of different ways of data representation • Computer-based simulations as a pedagogical tool for visualization and developing conceptual understanding • Stand-alone applets provide students visual, interactive and dynamic environment to explore concepts.
Develop statistical thinking and reasoning	• Development of a critical and questioning attitude when presented with claims made without proper statistical foundation. (Watson, 1997) • Critical thinking about statistics as used in arguments and good decision-making based on that information (Ramsey, 2002; Schield, 2002)	• Multimedia resources, web-based videos and movies provide the medium for investigation of real life problems in society involving data . • Compendium of statistics teaching-learning resources such as CAUSE website provide class activities, datasets, applets, video series for developing statistical thinking and reasoning.
Develop Data-handling and analysis skills	• Ability to organize and present data effectively in tables and graphical displays • Ability to organize, analyze, interpret, infer or make sense out of data (Del Mas, 2002)	• Statistical software packages and spreadsheets reduce time for organizing data into tables and graphs, calculating descriptive measures, finding confidence interval estimates of parameters, and performing tests of hypothesis.
Culminating Student Outcome	*Good Statistical Citizenship:* An informed, statistically literate citizen who can comprehend and deal with uncertainty, variability, and statistical information in the world around them, and participate actively in an information–laden society. (Gal and Garfield, 1997).	

As shown in Table 2A, an undergraduate introductory statistics course should provide a more balanced perspective between descriptive and inferential statistics that builds students' skills from data awareness and sense-making towards data production, description, analysis, and inference. In this context, technology plays an important role in exploring data, designing data production, and in processing, analysis, and making inferences with data. The course does not make one a statistician; nevertheless, it is an avenue for the development of a statistically literate citizenry who are able to use and make sense out of data in more meaningful contexts.

At the graduate level, many programs in non-statistical disciplines require statistics and research methodology as basic courses. Research literature has well documented the link between the teaching of statistics and research methods courses to meet the demands of statistical and research competence in an evidence-based society (Schuyten, 2001; Reston, 2007; Harraway, 2010; Lancaster 2010). In a discussion document in one of the Round Table Conferences of the International Association for Statistics Education (IASE) , statistics is considered as "an important component in the training of new researchers within Master's and doctorate courses" (Schuyten, 2001). Graduate statistics education is also one effective means of developing research capacity in specific fields (Reston, 2007).

Watson's and Callingham's (2003) model of statistical literacy as a complex hierarchical construct provides a framework for analysis of adult statistical literacy. The model comprises six levels: (1) idiosyncratic-personal engagement with context using basic graph/table reading skills; (2) colloquial-informal engagement with context using basic chance, graph, and numeracy skills; (3) selective engagement with context involving qualitative interpretation of statistical ideas; (4) appropriate non-critical engagement with context using basic statistical skills; (5) critical-questioning engagement with context using appropriate statistical terminology; and (6) critical-questioning engagement with context using sophisticated mathematical-statistical understanding**.** Thus, for graduate statistics courses, the goals for teaching statistics will move towards the development of higher levels of statistical literacy, statistical thinking and reasoning, and *statistical and research competence.* These ideas are summarized in Table 2B.

In Table 2B, we see two student outcomes at the culmination of statistics education for non-majors: the development of "*good citizenship*" in an information- driven society and the development of statistical competence and "*research scientist*" skills. The achievement of this broadly defined instructional vision may extend over several years or levels of schooling or over several statistics courses from undergraduate to graduate level (Gal and Garfield, 1997). The skills to be developed in statistics education may be categorized into two clusters: (1) "doing" statistics which encompasses understanding the purpose, logic and process of statistical investigations, mastery of procedural skills; and understanding mathematical relationships, probability and chance; (2) sense-making, research and communication skills which comprises the development interpretive and statistical literacy skills, and useful statistical disposition.

Dansie expounded on the role of statistical education in developing graduate qualities. He contended that "many of these contemporary directions for the introductory statistics course are in good alignment with the general move towards outcomes based education and statements of graduate qualities" (2005, p.1). He further noted that the notion of graduate qualities provides a framework for curriculum development but poses a number of challenges since many academic institutions have these statements written at a very broad level and assume that students will be able to apply them in a range of contexts within a profession, as a global citizen and individually as a lifelong learner (Dansie, 2005).

Table 2B. Mapping Out Goals of Graduate Statistics Education vis-à-vis Intended Learning Outcomes and Role of Technology in the Designing Learning Experiences

Goals	Significant Student Outcomes	Role of Technology
Develop Higher Levels of Statistical Literacy, Critical Thinking and Reasoning	• Levels 5 and 6 of Watson's and Callingham's (2003) Model of Statistical Literacy • Ability to connect statistical knowledge, procedures and principles with research-related tasks within their degree program and in their respective work settings. • Ability to evaluate intelligently and critically the results of quantitative research and other statistical investigations	• Data Repositories and web-based journal publications provide the data and research contexts for investigation and critical evaluation of data-based conclusions • Course management systems provide communication tools (such as discussion forums, file exchange), productivity tools (e.g.online student guide), and student involvement tools (group work, self-assessment, and electronic portfolios) .
Develop Statistical Competence	• Ability to formulate and ask the right questions, formulate hypotheses, choose the right study design, collect data effectively, choose statistical methods, summarize, present and interpret results. • Technological fluency in "doing statistics" using real world data that occur in specific contexts such as in their professional work settings.	• Online data repositories and published articles with real data sets • Statistics Online Computational Resource in www.SOCR.ucla.edu • Statistical software packages will aid data analysis • A course disk which contains syllabus, content, software, data files, video lectures , and pertinent website links will promote independent work.
Develop Research Scientist Skills	• Ability to critically read and synthesize a number of journal articles on a topic and make sense of the statistical information contained therein. • Competence to undertake independent research in an area of specialization and communicate the findings and their implications to diverse audiences.	• Evaluation of web-based journal publications that illustrate various statistical procedures and research methods • Use of on-line research resources for literature review, data production and analysis • Optimal use of technology tools in the conduct of one's own research
Culminating Student Outcome	*Statistical and Research Competence* *An informed citizen* who is able "to comprehend and deal with uncertainty and variability, and statistical information in the world around them, and participate actively in an information–laden society." A *statistically competent citizen* who is able to "contribute to or take part in the production, interpretation, and communication of data pertaining to problems they encounter in their professional life." (Gal & Garfied, 1997)	

4. CONCLUSIONS AND FUTURE DIRECTIONS

The framework presented in this paper for technology integration in higher education statistics classes for non-majors may serve well to respond to the recent and on-going reforms in Philippine Higher Education. With mathematics and statistics as a core subject area in the Revised General Education curriculum at the tertiary level, the framework addresses the need for vertical articulation in the goals and outcomes of teaching of statistics for non-majors as students move from undergraduate to graduate statistics courses. The goals for teaching statistics to non-specialists require increasing levels of statistical literacy, critical thinking, reasoning and competence in dealing with multiple forms of expressions with data in line with the goals of higher education. In course design, statistics teachers may be guided by the framework in designing class activities and requirements with increasing level of independence and multiple forms of technology use in these statistics courses. Through these activities, students may be provided the opportunity to develop various 21st century skills involving technological fluency from operational use of technology resources in the management and analysis of data to various forms of data production, creative representations and statistical applications in research.

Moreover, while different forms of technology tools are available virtually through the World Wide Web that can provide extended learning opportunities for students' successful attainment of the intended learning outcomes, the reality of Philippine conditions in terms of available physical facilities, teacher preparation in technology integration and other administrative barriers needs to be considered. The recent and on-going *K to 12* Basic Education reform and the revision of the General Education curriculum at the tertiary level provide opportunities to assert the vital role of statistics towards the development of knowledge and skills for the 21st Century learner.

Further, there is a need for balance in meeting the demands of global standards of statistics instruction and considerations of the local situation, needs and resources available. This is the idea behind the concept of "*glocalization,*" a blending of the words, "global" (or *globalization*) and "*localization*". Applying the concept of "*glocalized*" education to technology integration in statistics education implies meaningful integration of technology resources available globally with data sets and technology tools available locally as a means towards a more relevant and contextualized statistics education. With the prohibitive cost of licensed statistical software packages, statistics educators in the Philippines can leverage on available open-source technology tools from the World Wide Web while at the same time using local data in order to be relevant and responsive to local contexts. Most colleges and universities have computer laboratories with internet connectivity, so a first step toward this end may be the institutionalization of a laboratory component in statistics courses in both undergraduate and graduate levels.

From a broader perspective, the Philippine context in coping with the global demand for technological fluency in dealing with data and the framework presented in this paper will provide an example for other developing countries who share the same concerns in improving the outcomes of statistics education. In particular, the proposed framework provides a guide for a coherent and outcome-based statistics education that focuses on the attainment of significant learning outcomes. Grounded on the goals of statistics education, the framework uses the principles of Outcome-Based Education and other sound educational models to map out the desired learning outcomes expected of professionals in this Age of Information and the corresponding role of technology in designing significant learning experiences geared towards the attainment of these outcomes. This organizing framework cuts across levels of statistics instruction in higher education to ensure that course goals, content, learning experiences, technology integration and assessments build one upon another and that prerequisites are mastered, gaps are eliminated, and sophistication and rigor are increased in teaching concepts, processes and skills across various levels culminating in the demonstration of significant learning outcomes for all students.

Indeed statistics is an important component in the general education courses of higher education programs as it plays a vital role in the goal of developing competent professionals who can take active roles in the generation, communication and expansion of knowledge through research in the their respective fields. As universities are expected to produce through research the necessary knowledge-base upon which the socio-economic, scientific and technological systems of a country are grounded, it is important to develop well-informed and statistically competent professionals through an outcome-based and coherent statistics education. The challenge remains for statistics educators to design learning experiences that effectively integrate technology in building conceptual understanding of statistical concepts while at the same time, enabling students to appreciate learning that involves integrated data management and research skills, as well as communication, problem-solving, decision-making and other real life skills needed to cope with the global demands of the 21st century workplace.

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