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**Scientific International Journal™**  
605 Condado Street, Suite 706  
San Juan, Puerto Rico 00907  
787-550-5964  
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Cover graphic design:  
Jonathan Castro

Developed in Puerto Rico.

**ISSN 1548-9639 (print)**

**ISSN 1554-6349 (online)**

**Vol. 9 No. 3 September–December 2012**

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**“Notification of Violation of the Publication Principles of  
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After a careful and exhaustive revision, by the Editorial Advisory Board of Scientific International Journal™ (SIJ) and the Ethics Committee of Non-Profit Evaluation & Resource Center, Inc., of the content of the article “Peace Education in the Lebanese Curriculum” submitted by Dr. Khayrazad Kari Jabbour and published in SIJ Vol. 9 No. 3 (September-December 2012), it was corroborated that Dr. Khayrazad Kari Jabbour violated the Publication Principles of SIJ when the original text of the doctoral dissertation entitled “A National Peace Education Program in Lebanon: Exploring the Possibilities from the Leaders’ Perspectives” was duplicated without the appropriate authorization from the authors, Dr. Harvey N. Oueijan and Dr. Joseph M. Tannous, and without citing the original references. Due to the nature of this violation, it is requested to the readers of SIJ to eliminate the reference to Dr. Khayrazad Kari Jabbour’s article and, instead, use the following reference:

A National Peace Education Program in Lebanon:  
Exploring the Possibilities from the Leaders’ Perspectives

Dr. Harvey N. Oueijan and Dr. Joseph M. Tannous

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Department of Education and Public Health at Saint Louis University, USA

# MEASUREMENT OF SATISFACTION WITH THE ONLINE AND CLASSROOM TEACHING METHODOLOGIES OF GRADUATE STUDENTS AND ITS IMPLICATIONS FOR ACADEMIC ACHIEVEMENT

Mylord Reyes Tosta, EdD

## Abstract

This research study was performed in 2011. It was an exploratory study with a quantitative approach. This design was used based on the objectives of the study and it included the development of a valid and reliable instrument to obtain baseline data on the satisfaction and academic achievement of the students receiving online courses and classroom courses. A comparison was made between the two types of teaching methodologies. The study was conducted with master level students of the School of Business and Entrepreneurship at a private university in the central region of Puerto Rico. A convenience sample of 74 students was selected. The data collection method was a survey and the instrument developed had a Likert scale. The results about the academic achievement and satisfaction of the students are presented by gender. The results indicated that there was not a statistically significant difference between the two teaching methodologies for both satisfaction and academic achievement. Furthermore, there was not a statistically significant difference by gender within each of the two teaching methodologies.

**Keywords:** students' satisfaction, students' academic achievement, online methodology, classroom methodology

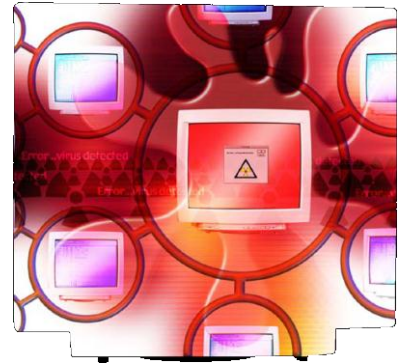
## Resumen

Este estudio de investigación se llevó a cabo en el año 2011. Expone un enfoque cuantitativo de tipo exploratorio. Este diseño fue usado basado en los objetivos del estudio e incluyó el desarrollo de un instrumento válido y confiable para obtener datos básicos iniciales sobre la satisfacción y el aprovechamiento académico de los estudiantes que recibieron cursos en línea y cursos presenciales. Se hizo una comparación entre ambas modalidades de enseñanza. El estudio se llevó a cabo con estudiantes en el nivel de maestría de la Escuela de Negocios y Empresarismo de una universidad privada en la región central de Puerto Rico. El tipo de muestreo que se utilizó fue por conveniencia y la muestra fue de 74 estudiantes. El método de recolección de datos fue una encuesta y el instrumento desarrollado tenía una escala tipo Likert. Los resultados sobre el aprovechamiento académico y la satisfacción de los estudiantes se presentan por género. Los resultados indicaron que no existe una diferencia estadísticamente significativa entre las dos modalidades, tanto en satisfacción, como en aprovechamiento académico. Además, no existe diferencia estadísticamente significativa por género dentro de cada una de las dos modalidades de enseñanza.

**Palabras claves:** satisfacción de estudiantes, aprovechamiento académico de estudiantes, modalidad en línea, modalidad presencial

## INTRODUCTION

**T**his manuscript was written with the purpose to inform the entire school community and other interested individuals of the findings from a study comparing the level of satisfaction with online courses and classroom courses. These results on satisfaction and academic achievement may be the starting point for making decisions aimed at improving academic structures and processes of graduate schools. The growth of higher education through online courses in Puerto Rico is remarkable (Núñez, 2009). Therefore, it was necessary to know its status as there are many technological devices involved in the processes and they change very often. This is a recent perspective of the teaching-learning process that has important implications for attitudes and academic performance of students by being a method that uses new technologies and breaks with the uses, paradigms and ideologies that precede it.



Taking this into account, this study scientifically examined what was the degree of satisfaction and academic achievement of students who participated in online courses while they were still immersed in traditional education. In addition, an instrument was developed and validated to collect the information according to the nature of education in Puerto Rico. The validation process provided valuable information to the study. Different theories were strongly influenced by research in the field of business (Pichardo, Garcia, De la Fuente & Justicia, 2007) and this fact should provoke greater interest in knowing the satisfaction of university's students as a variable to consider in improving the quality of the services of higher education institutions.

## OBJECTIVES

**T**he following were the objectives of the study:

A) To design and validate a data collection instrument to determine student's satisfaction with the online and classroom courses.

B) To measure student's satisfaction with the online and classroom courses.

C) To identify the difference in student’s satisfaction between the online courses and classroom courses.

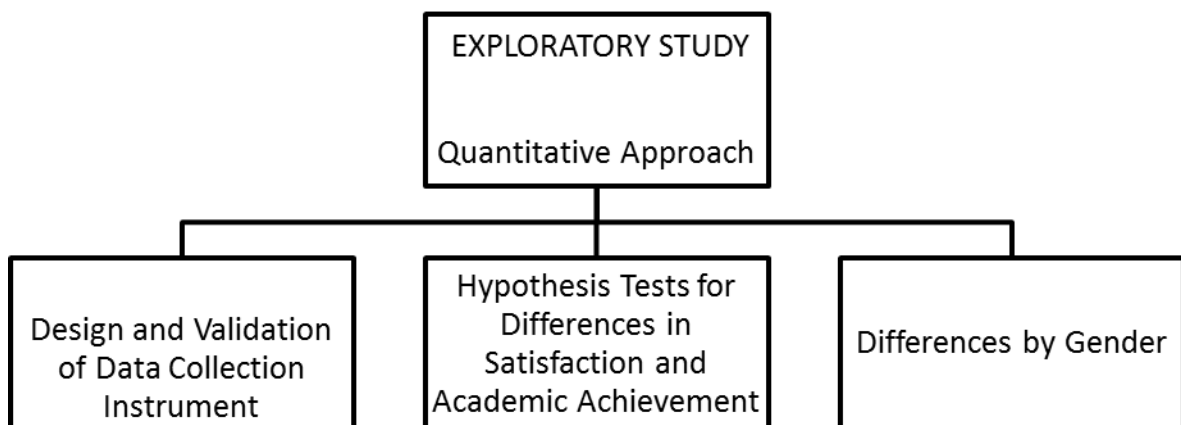
D) To identify the difference in student’s academic achievement between the online courses and classroom courses.

E) To describe the gender differences found in the academic achievement of students within each of the two types of teaching methodologies.

F) To describe the gender differences found in student’s satisfaction within each of the two types of teaching methodologies.

**DESIGN**

**T**his study used an exploratory design (Figure 1). According to Waters (2007), exploratory research provides an understanding of a phenomenon or situation. It is a type of research conducted when a problem has not been clearly defined and it helps determine the best research design, method of data collection and selection of subjects. It allows definitive conclusions, only with extreme caution. DJS Research Ltd. (2010) stated that, unlike descriptive research, the exploratory research is used primarily to obtain a deeper understanding of something. Its design is more flexible and dynamic than descriptive research. In general, it research trends, identifies potential relationships between variables and set the tone for more rigorous subsequent research.



**Figure 1. Study Design Diagram**

## SAMPLE

This study was performed in 2011 and a convenience sample was used to identify the sections for the two teaching methodologies (online courses and classroom courses). The sample for the two teaching methodologies consisted of 74 graduate students at the master level who enrolled in Human Resources Management (HURM 710) and Organizational Behavior (MANA 501) courses (Table 1).

**Table 1. Distribution of Study Sample by Course and Gender**

Gender	Course									
	HURM 710 Online	%	MANA 501 Online	%	HURM 710 Classroom	%	MANA 501 Classroom	%	Total	%
Male	7	41%	3	21%	6	30%	8	35%	24	32%
Female	10	59%	11	79%	14	70%	15	65%	50	68%
Total	17	100%	14	100%	20	100%	23	100%	74	100%

## DATA COLLECTION INSTRUMENT

The data collection instrument designed for the survey was a questionnaire (Table 2) and it consisted of 48 items using a 5-point Likert scale, where 5=Very satisfied (VS), 4=Satisfied (S), 3=Somewhat satisfied (SS), 2=Dissatisfied (D), 1=Very dissatisfied (VD) and Not applicable (N/A). A panel of experts was used for the validation of this instrument and a Cronbach's alpha coefficient was calculated after its administration to measure its reliability (quantitative indicator of content validity). All students' academic achievement measurement was completed based on the final grades obtained by the students in each course. The final grades were offered by the students in the survey. The survey was anonymous and personal and/or sensitive data was not requested.

**Table 2. Satisfaction Survey with Teaching Methodology**

**SATISFACTION SURVEY WITH TEACHING METHODOLOGY**

**Part I: General information**

**Instructions:** Please enter the date you completed this survey and mark in the blank if you are enrolled in an online course or classroom course and your gender (male or female). Also, write the name of the course and check the grade obtained.

Date: \_\_\_\_\_ Online course: \_\_\_\_\_ Classroom course: \_\_\_\_\_

Gender: \_\_\_\_\_ Male \_\_\_\_\_ Female

Course name or code: \_\_\_\_\_

Course grade: A \_\_\_\_\_, B \_\_\_\_\_, C \_\_\_\_\_, D \_\_\_\_\_, F \_\_\_\_\_

**Part II: Measurement of satisfaction with teaching methodology**

**Instructions:** Below is a list of independent variables that measure your satisfaction with the teaching methodology. Please read carefully each one and mark (x, √) the option that best describes your opinion using the following scale:

Scale: 5=Very satisfied (VS), 4=Satisfied (S), 3=Somewhat satisfied (SS), 2=Dissatisfied (D), 1=Very dissatisfied (VD) and Not applicable (N/A).

<b>Variables to measure satisfaction</b>	<b>5 (VS)</b>	<b>4 (S)</b>	<b>3 (SS)</b>	<b>2 (D)</b>	<b>1 (VD)</b>	<b>N/A</b>
1. Student and instructor interaction						
2. Faculty feedback to student progress						
3. Time to get the course						
4. Homework delivery time						
5. Course period						
6. Professor response to questions from the students						
7. Student-to-student collaborations						
8. Communication between teacher and student						
9. Teacher assistance to solve student problems						
10. Group work results						

<b>Variables to measure satisfaction</b>	<b>5 (VS)</b>	<b>4 (S)</b>	<b>3 (SS)</b>	<b>2 (D)</b>	<b>1 (VD)</b>	<b>N/A</b>
11. Student's learning styles considered when designing course strategies						
12. Techniques used by the teacher to teach the course						
13. Integration of theory with practice						
14. Activities used to support the practice						
15. Activities used in the course according to the objectives						
16. Teacher content mastery						
17. Updating the content of the course by the teacher						
18. Course management for self-motivation of the students						
19. Availability of the course syllabus provided by the professor						
20. Teacher's support on time outside the classroom						
21. Technology according to the course objectives						
22. Initial instructions on the use of technology						
23. Information technology resources available						
24. Teacher technology mastery						
25. Technology resources updating						
26. Registration services						
27. Payments services						
28. Financial aid services						
29. Programmatic services						
30. Updated library services facilities and physical information resources						
31. Updated library services related to virtual information resources						
32. Library services schedule						
33. Library environment						
34. Library services' customer support quality						
35. The course curriculum provides achievable objectives						



<b>Variables to measure satisfaction</b>	<b>5 (VS)</b>	<b>4 (S)</b>	<b>3 (SS)</b>	<b>2 (D)</b>	<b>1 (VD)</b>	<b>N/A</b>
36. Objectives of the course curriculum are aligned to its content						
37. Fulfillment of course objectives						
38. Upgrading of course curriculum						
39. Effectiveness of student's formative evaluation						
40. Effectiveness of student's summative evaluation						
41. Techniques used in the evaluation according to course content						
42. Equivalence in the qualitative and quantitative student's evaluation						
43. Student's assessment feedback						
44. Physical facilities accessibility						
45. Facilities environment						
46. Facilities food availability						
47. Facilities health services						
48. Facilities maintenance						

## DATA ANALYSIS

**D**escriptive and inferential statistics were used for data analysis. The statistics used to answer all research questions are presented below.

1. Frequency distribution table for both satisfaction survey and the students' grades for each of the courses.
2. Table of descriptive statistics for the satisfaction survey and the grades of the students (mean and standard deviation). These were used to enable the reader to visualize and better understand the results showed by the inferential statistics.
3. Cronbach's alpha coefficient to measure the reliability of the instrument.
4. Nonparametric statistics (Mann Whitney U Test) for independent samples were used at a 0.05 significance level. They were used to establish whether there was a statistically significant difference between the two methodologies related to satisfaction (Jandaghi & Matin, 2009).

5. A hypothesis test for two independent means was performed, using the Mann Whitney U Test, to establish whether there was a statistically significant difference between students' grades for both types of teaching methodologies.

6. A hypothesis test for two independent means was performed, using the Mann Whitney U Test, to determine whether there was a statistically significant difference in students' grades by gender within each of the two types of teaching methodologies.

7. A hypothesis test for two independent means was performed, using the Mann Whitney U Test, to establish whether there was a statistically significant difference in student satisfaction by gender within each of the two types of teaching methodologies.

The Kolmogorov-Smirnov/Shapiro-Wilk Test was used for testing normality of the data and, to establish the differences by group, the nonparametric tests Mann-Whitney and Kruskal Wallis were used because not all data fulfilled the assumption of normality, except one of the variables of satisfaction. In this last case, the t test was used. An alpha of .05 (Type I error) was used in all hypotheses tests of this study. The Statistical Package for Social Science (SPSS) was used for statistical calculations.

## ANSWERS TO RESEARCH QUESTIONS

**B**ased on the results obtained from the data analysis of this study, the answers to the five research questions are presented below.

1. What are the psychometric properties of the data collection instrument?

The psychometric properties of the data collection instrument were established by the reliability given by the Cronbach's alpha coefficient, which measured the internal consistency of the scale. That is, the linear correlation between item and total score was established. The Cronbach's alpha coefficient was .984 for both teaching methodologies according to participants' responses. The Cronbach's alpha coefficient contributed to the high degree of reliability of the data collection instrument. The results compare favorably with the statement of Kim & Feldt (2010), when they indicated that a coefficient higher than .70 provides an acceptable reliability of the instrument.

2. Is there a statistically significant difference in student's satisfaction between the methodologies of online courses and classroom courses?

The hypothesis test of Mann Whitney U showed a result of  $p = .295$  ( $p > .05$ ). Therefore, the null hypothesis was retained and the alternate hypothesis was rejected. There was not a statistically significant difference in student’s satisfaction between the methodologies of online courses and classroom courses. The nonparametric test of Mann Whitney U was used because the data did not show normality (Table 3).

**Table 3. Student’s Satisfaction Normality Test by Methodology**

Methodology	Normality Test
Online Courses	.012
Classroom Courses	.003

3. Is there a statistically significant difference in the academic achievement of the students between the methodologies of online courses and classroom courses?

The hypothesis test of Mann Whitney U showed a result of  $p = .774$  ( $p > .05$ ). Therefore, the null hypothesis was retained and the alternate hypothesis was rejected. There was not a statistically significant difference in the academic achievement of the students between the methodologies of online courses and classroom courses (Table 4).

**Table 4. Average, Standard Deviation, and Hypothesis Test of Academic Achievement by Methodology**

Methodology						Hypothesis Test
Online Courses			Classroom Courses			
n	M	SD	n	M	SD	Significance
31	3.74	0.44	43	3.67	0.47	.774

4. Is there a statistically significant difference in academic achievement by gender within each of the two teaching methodologies?

The hypothesis test of Mann Whitney U showed a result of  $p = .533$  ( $p > .05$ ) in the comparison of the academic achievement by gender in the online methodology. Therefore, the null hypothesis was retained and the alternate hypothesis was rejected. There was not a statistically significant difference in the academic achievement of the students by gender for the methodology of online courses. Moreover, the hypothesis test of Mann Whitney U showed a result of  $p = .699$  ( $p > .05$ ) in the comparison of the academic achievement by gender in the classroom methodology. Therefore, the null hypothesis was retained and the alternate hypothesis was rejected. There was not a statistically significant difference in the academic achievement of the students by gender in the methodology of classroom courses (Table 5).

**Table 5. Average, Standard Deviation, and Hypothesis Test of Academic Achievement by Methodology and Gender**

Methodology	Gender						Hypothesis Test
	Male			Female			
	n	M	SD	n	M	SD	Significance
Online Courses	10	3.80	0.42	21	3.71	0.46	.533
Classroom Courses	14	3.64	0.50	29	3.69	0.47	.699

5. Is there a statistically significant difference in student's satisfaction by gender within each of the two teaching methodologies?

The hypothesis test of Mann Whitney U showed a result of  $p = .118$  ( $p > .05$ ) in the comparison of satisfaction by gender for the online courses. Therefore, the null hypothesis was retained and the alternate hypothesis was rejected. There was not a statistically significant difference in student's satisfaction by gender in the methodology of online courses. Moreover, the hypothesis test of Mann Whitney U showed a result of  $p = .136$  ( $p > .05$ ) in the comparison of student's satisfaction by gender in the methodology of classroom courses. Therefore, the null hypothesis was retained and the alternate hypothesis was rejected. There was not a statistically significant difference in student's satisfaction by gender in the methodology of classroom courses (Table 6).

**Table 6. Results of Hypothesis Test of Total Satisfaction by Gender and Methodology**

Satisfaction by Gender and Methodology	Hypothesis Test
	Significance
Satisfaction by Gender for Online Courses	.118
Satisfaction by Gender for Classroom Courses	.136

## DISCUSSION AND EDUCATIONAL IMPLICATIONS

The results of this study coincided with the study of Alonso et al. (2009), which purpose was to determine if the results of distance learning using a particular teaching methodology are comparable with the traditional teaching methodology (face to face). The results indicated that the degrees and levels of satisfaction were similar for the students studying through distance and traditional learning. Moreover, in the study of Markauskaite (2006), who sought gender differences in three satisfaction variables in graduate students candidates to be teachers, no significant differences were found between female and male on experience and literacy related to information and communications technology (ICT). This gender comparison of Markauskaite coincided with the present study, but did not match the other variables where significant differences were found. However, in the study of Dolan (2008), no statistically significant differences were found in any of the 14 variables of satisfaction with the course in the comparison between the online methodology and the classroom methodology. Therefore, the results of the Dolan's study concur with the results of this study.

These results are in accord with those obtained in a study by Liedholm and Brown (2001), where no statistically significant difference was found between men and women from a group of college students taking a graduate level course online. Moreover, in the classroom course, the findings were not consistent because the study of Liedholm and Brown did find a significant difference in men with a higher performance. They stated that this finding was consistent with previous research showing that many women do

better in online courses than in classroom courses. The same trend was found in the results of this study.

Also, the results of this study agree with those of Stewart, Choi & Mallery (2010) who found similar results in the two teaching methodologies of their study, which purpose was to investigate whether the academic achievement of students, measured by the grades, differ between the online course and the traditional course. The results of the study of Choi & Johnson (2005) were similar and did not find a statistically significant difference between the two methodologies, where the mean for the online course was 20.06 and the mean for the traditional course was 19.88. The study of Ellis (2005) also found results suggesting that students in the traditional classroom and virtual classroom executed at a similar level.

Very similar results to this study were those of Gratton & Stanley (2009), who investigated the gender difference between the two teaching methodologies. The results did not show statistically significant differences in both methodologies of teaching and in the gender comparison. However, the raw data reflected a higher average in online learning and for males.

A similar scenario was the study of Barrett & Lally (1999), which explored gender differences in students in online courses at the graduate level in the use of communication through computers in a specific learning context. As for the grades, the performance of females and males was similar, but their social and interactive behavior differed significantly. In the study by Price (2006), in terms of academic achievement in online courses, there were statistically significant differences between females and males, higher for females. As for the academic achievement of traditional courses, there was not a statistically significant difference between females and males.

But beyond this discussion about the results of comparable studies, this study on the comparison of teaching by two courses delivered through online and traditional methodologies to graduate students, using the results on levels of student's satisfaction and grades from both groups in the same course, produced straighten data on the attitude and cognitive aspects. A very important fact about this study is its contribution to strengthen the procedure used toward the search for more comprehensive results, because an instrument to measure student satisfaction was created and validated. This instrument

consisted of a questionnaire using a Likert scale to measure 48 independent variables (causes) which affect satisfaction (the dependent variable or effect). The instrument had a holistic design that included both the online and classroom methodologies. It was validated and its reliability was established, therefore, it can be used by other researchers, teachers and the educational community.

The results obtained in this study showed that there were not statistically significant differences by type of teaching and gender for the satisfaction and academic achievement variables. This new scenario now known, offers more information to make better decisions to maximize the quality of the educational processes. Another contribution evidenced by the results of this study was the possibility to answer any questions that many students and education professionals have about the effectiveness of the information and communications



technology. Also, to have a clearer vision of the implications of the cost of technology on the productivity of higher education, in terms of satisfaction and academic achievement, is a benefit because it allows improving the strategies used in the teaching learning processes. Additionally, it allows creating expectations about the direction that technological advances in the field of education could have. Therefore, more research is needed to know if some of the paradigms that have survived in traditional education are ready for change.

This paradigmatic, structural, procedural and philosophical shift could be mainly due to rapid advances in information and communications technology. These technological advances have improved the quality of processes and outcomes, have saved time and effort because the devices are more efficient and have removed physical spaces because there is no distance, in terms of communication. Thus, with the acceptance of these benefits, there is less resistance to change every day.

## CONCLUSIONS

The results of this study suggested that a well-designed online course can be as efficient and effective as a well-designed course in the traditional methodology. Also, it was inferred that the fact that the online methodology using the Blackboard platform was more recent and unknown to many, does not mean students cannot achieve high levels of academic achievement and satisfaction.

Moreover, a valuable contribution of this study was the design of a data collection instrument that was validated by a panel of experts and its reliability was established through the Cronbach's alpha coefficient. A correlation coefficient of .984 contributed to the high degree of reliability of the data collection instrument. The data collection instrument consisted of a survey using a Likert scale to measure 48 independent variables (causes) which affect satisfaction, the dependent variable (effect). The data collection instrument considered the most important components of an institution of higher education and is of great relevance for students. It was evaluated by participants to determine their satisfaction, aspects directly related to teacher effectiveness, student performance, technology, administrative and program services, physical and virtual library services, course curriculum and physical facilities. In addition, the instrument provided the student's performance on the course and it was applied to both, students of online courses and classroom courses.

This study did not find statistically significant differences in the satisfaction and academic achievement of the participants according to the responses obtained through the survey. In the hypothesis tests performed between the online and classroom methodologies, there was not a statistically significant difference in satisfaction and academic achievement. The same results were obtained in the hypothesis tests performed by gender, comparisons within online courses and within classroom courses. That is, it did not find statistically significant differences in overall satisfaction and academic achievement by gender in any of the two types of teaching methodologies.



## RECOMMENDATIONS

**B**ased on the findings of this study on measuring satisfaction and academic achievement of students and its comparison between teaching methodologies, including gender, recommendations were made for graduate schools with online and classroom teaching methods. For managers and administrators, it was recommended to include more research courses in the academic programs, expanding the fields of study that include online courses and finding strategies to motivate students to learn this methodology. Also, encourage faculty to engage in research proposals.

For the faculty, it was recommended to encourage students to collaborate on research, highlighting the importance for themselves as students and for the educational community. Also, for the research and evaluation courses, to present, as a topic of discussion, the data collection instrument produced in this study to analyze it in all its parts. In addition, to post in the Internet the results of past and future research completed in the courses.

For other researchers, it is recommended to conduct studies on academic achievement and satisfaction in both teaching methodologies at the undergraduate level, including other public or private universities, and a qualitative approach regarding its advantages and disadvantages. Also, it is recommended to investigate the factors influencing student's academic achievement and satisfaction for online and classroom methodologies. In addition, based on the results of this study, it is recommended to conduct studies using a quantitative design with treatment in the experimental group and with a control group.

It is recommended that educational researchers use the reliable and validated data collection instrument produced in this study. Given the features, design and scope of this instrument, researchers can use it for public and private universities, for undergraduate and graduate levels, and for any course and academic area. It is easily adaptable to suit the needs of each study and applies to both types of teaching. In general, the components of this instrument covers the most important of all academic structure, known until now, allowing the researcher to obtain necessary and sufficient data to draw conclusions.

Given the importance of data collection instruments for achieving the goals of research, it is encouraged to use other methods to measure the reliability of the instruments, and make comparisons between them. Moreover, it is recommended to Puerto Rican researchers, to publish the results of their studies. In the literature review conducted for this study was not possible to find data related to the research problem within the educational environment of Puerto Rico.

## ACKNOWLEDGEMENTS

The author is particularly grateful to Dr. Edgardo Quiñones who was the Dissertation Committee Director and the other Dissertation Committee members: Dr. Alicia González and Dr. Zaida Vega. The author is also grateful to Dr. Lizzette Rojas and Dr. Flordeliz Serpa who were readers of this research study and Dr. Marcelino Rivera and Turabo University's administrators for their support throughout the process.

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# **EDUCATIONAL RESOURCES ON THE WEB REGARDING WASTE MANAGEMENT, RECYCLING AND EXTENDED PRODUCER RESPONSIBILITY**

Prof. Aldo T. Marrocco

## **Abstract**

The educational resources presented in this paper consist of text, images, videos, animations and games. They can be used for teaching about waste recycling, with the method that the teacher considers most appropriate. Part of the manuscript is devoted to the concepts of Extended Producer Responsibility, which now is the inspiration for the legislation of some countries. The laws on Extended Producer Responsibility are creating design changes in products so that they are more easily and economically manageable at end-of-life, both for recovery and recycling of materials.

**Keywords:** extended producer responsibility, recycling, waste

## **Resumen**

Los recursos educativos presentados en este artículo consisten de textos, imágenes, videos, animaciones y juegos. Pueden ser usados para la enseñanza relacionada al reciclaje de desperdicios, utilizando el método que el maestro considere más apropiado. Parte de este manuscrito está dedicado a los conceptos de Responsabilidad Extendida del Productor, lo cual es la inspiración para legislación en algunos países. Las leyes sobre Responsabilidad Extendida del Productor están creando cambios en los diseños de los productos para que sean más fácilmente y económicamente manejables al final de su vida útil, tanto para la recuperación como para el reciclaje de los materiales.

**Palabras claves:** responsabilidad extendida del productor, reciclaje, desperdicios

## OVERVIEW AND INTRODUCTION

Population growth on a global scale and other socio-economic changes taking place in the world contribute to an increase in the amount of waste generated. Affluence is associated with waste production; the citizens of the richer countries generally produce more waste than the others. The emerging economies increasing their wealth, in their turn, tend to produce more waste. There is a trade in waste for recycling.<sup>1,2</sup> Recycling activities are growing, but their intensity should be further increased. Waste reduction at source should also be pursued, in order to successfully reduce the related pollution.<sup>3</sup>

According to a document from the World Bank, Europe is facing a huge cost for the cleaning up of soils and ground waters contaminated by illegal dumping.<sup>4</sup> In Europe it is, therefore, being experienced that the organization of a proper waste disposal system, earlier, would have been much cheaper and, above all, less harmful for the environment and human health. The Great Pacific Garbage Patch is an area of marine debris concentration in the North Pacific Ocean; the debris type mainly found here consists in floating plastic pieces.<sup>5</sup> In several articles, the size of this patch has been compared in extent to the area of a large American state. In reality, the area of this large and continuously moving garbage patch is difficult to measure accurately; some videos show its images.<sup>6</sup> Still today, Europe and USA recycle only 21.3% and 7% of plastic, respectively.<sup>7,8</sup> These facts, among many others, may suggest the opportunity of a more rational waste management on global scale.

A technique that reduces the mass of municipal solid waste (MSW) consists in their incineration. Nevertheless, in several countries there is the tendency, still, according to the above mentioned document of the World Bank, to reduce the use of incinerators. The operation of the latter is, in fact, associated with emissions of toxic substances including dioxins, furans and mercury. In addition, the toxic ash left after incineration must, then, in its turn, be disposed of in landfills. Furthermore, incinerators are capital intensive, and their duration is limited to 20-30 years.

In the most modern sanitary landfills the methane produced by the fermentation of organic matter in the absence of oxygen is recovered. This gas can be used as an energy source through its combustion, thus, avoiding, at the same time, its emission into the

atmosphere. This is important since methane, generated both from poorly operated landfills and from illegal dumping of MSW, constitutes the largest source of anthropogenic greenhouse gases. Methane is, in fact, known to scientists as having an influence on climate change 21 times more intense than carbon dioxide. The disposal of MSW in the most modern sanitary landfills entails also recovery and treatment of leachate that flows to the bottom from decomposing waste. Clearly, long-term experience does not yet exist on how long the bottom of such landfills can last and hence protect the groundwaters from leachate contamination. In regions with a high population density and relative scarcity of water, the aquifers are a resource of the utmost importance that needs to be protected carefully. In addition, waste disposal in landfills or incinerators can, at best, allow the recovery of the energy, but not of the materials, which often are not renewable.

Natural organic substances such as food waste and yard trimmings can constitute even 50% of the total mass of MSW. The presence of humid organic substances in the MSW destined for incineration lowers the combustion temperature and, thus, negatively impacts on emissions. When natural organic substances are separated at source, they can be used to produce compost and, in addition, the incineration of the remaining MSW proceeds with less toxic emissions. When MSW is to be landfilled, separating at source natural organic substances may greatly reduce the generation of methane, carbon dioxide and leachate.



## TEACHING TOOLS THAT DEAL WITH WASTE RECYCLING

**W**aste education perhaps cannot be considered a fascinating subject, but negative emotions can be overcome through knowledge which can dispel any misconceptions. Several years ago, in Pisa, a touring exhibition consisting of posters involved all the middle schools. This exhibition, visited by most classes of Pisa, dealt with the segregation of household waste at source for recycling. Many of these classes understood the importance of this subject and, autonomously, decided to ask the municipality to install

bins in the city for separate waste collection. The municipality decided to positively respond to the numerous requests by installing, in many parts of the city, the recycling bins. Through this touring exhibition, the goal of informing the classes was reached and, not less important, the commitment by the municipality was stimulated.

The teaching tools that deal with waste recycling have been downloaded for free from the Internet.<sup>9-23</sup> They consist of text, images, animations and games which may help get young students interested in this subject. They can be used with the method that the teacher considers most appropriate.

## CRITICAL METALS

The so-called “Critical Metals” (CM), because of the applications which they have in the environmental technologies (e.g. photovoltaic, automotive catalysts, electric cars), are considered important for sustainable development. Their utmost importance in the modern environmental technologies may stimulate the interest of young people. The CM have in common both a rapid growth in their global demand, and the creation of risks due to their physical scarcity or the regional concentrations of mining, which can be a source of tensions. A United Nations Environment Programme (UNEP) document deals with applications, reserves, recycling and related problems of this numerous group of chemical elements.<sup>24</sup> For example, 47% of the platinum (Pt) global demand is devoted to its applications in automotive catalysts. The price of Pt, pushed up by a continuous growth of the demand, almost quadrupled between 1998 and 2007. It can be efficiently recycled from its scrap, but the need is felt that more countries develop the necessary infrastructure for its collection. Most of Pt (77%) is mined in South Africa.

Indium (In) has several industrial applications. Its use in thin-film solar panels has a very strong growth potential and is pushing up demand. There are serious supply risks for In, since its global reserves are limited. Its price rose from 100 U.S. dollars/kg at the end of 2002 to 900 U.S. dollars/kg in 2006, then stabilizing around 500 U.S. dollars/kg. Indium pre-consumer recycling is practiced by the same industries that utilize In, using the scrap generated during the production process. Post-consumer recycling is practiced as well, thanks to the recovery of indium-containing old scrap. Japan, although not

having its own natural reserves, is the second largest producer of indium in the world, thanks to a well-organized recycling system. A major technical problem is its low concentration in the scrap that contains it. This makes the recycling of In difficult and expensive, nevertheless, it remains important.

Among the main industrial applications of lithium (Li) is the production of Li-ion batteries for mobile phones, laptop computers and electric cars. At the moment, the world reserves of lithium are not an immediate concern and, therefore, its low price does not stimulate recycling. This situation might quickly change, given that already there is a forecast of a quickly growing demand for electric cars with Li-ion batteries. In fact, this change may have a tremendous effect on the growth of Li global demand. A problem related to Li recycling consists in its oxidation during pyrometallurgical processes; it then moves into the slag phase as oxide. A share of 73% in the estimated global lithium reserves is located in Chile. Uncertainty about the future supply of these materials and an often difficult substitutability makes CM recycling of paramount importance. The need is felt that the recycling technology of some CM and the infrastructure for the collection of waste containing CM are better developed.

## EXTENDED PRODUCER RESPONSIBILITY

**T**wo documents on the Extended Producer Responsibility (EPR) could be useful for a teaching unit that introduces some concepts and information related to the zero waste philosophy.<sup>25,26</sup> In the optimistic hypothesis of a future World Community that recycles 60% of the MSW that it generates, the related environmental problem will be postponed, which is very important, but not resolved. This would mean, in fact, that still 40% of the MSW generated by the World Community in increasing amounts will have to be incinerated or landfilled, thus, increasing pollution and wasting materials.<sup>27</sup> This is clearly unthinkable in the view that human beings continue to live on our planet for thousands of years.

Nowadays, the necessary infrastructure for separate waste collection often does not exist. Furthermore, many materials cannot be recycled because of technical





difficulties and the costs of dismantling the objects from which the former can be extracted. Many parts are difficult and sometimes dangerous to remove; the labor for their recovery can constitute a threat for the health and safety of the operators. According to the concepts of EPR, which inspire the legislation of some countries, producers of consumer goods are responsible for collecting and disposing their own products, when these latter arrive at end-of-life. The producers are, thus, aware of bearing the disposal cost of what they produce. Hence, they are stimulated to design objects that are easily and economically manageable at end-of-life, both for the recovery and recycling of materials. In fact, the cost for end-of-life management depends on the labor required to dismantle products and on the disposal cost for material that cannot be recycled; the revenue obtained from the recovered materials can, of course, be subtracted. The cost of disposal is internalized into the price that the buyer pays at the time of purchase, thus, being supported by those who benefit from the product and not by all taxpayers.

Two documents from the Georgia Institute of Technology may help to understand the problems faced by designers to create products easy and cheap to dismantle for the recovery and recycling of materials.<sup>28,29</sup> The materials recovered can be altered, unrecognizable, or both, therefore, unusable. Moreover, the presence of toxic substances, whose legal disposal is expensive, adds to the cost of end-of-life management. In the automotive industry, a huge variety of plastics are used; they are often not compatible with each other, hence, they cannot be processed together. In addition, they are often difficult to distinguish from each other. Mixing for processing different types of recovered plastics leads to the so-called downcycling, which results in a product of lower quality which is difficult to recycle again, if at all. Even between plastics, and the paints used for them, there can be the possibility of compatibility or not. A batch of plastic to be recycled, if contaminated with paint, even to an extent of 1%, could be ruined. Consequently, the commercial value of many recovered plastics can be 3-10 times lower than the corresponding virgin material and often drops even to 0. A metal can have platinizing or weldings made with a different metal that often cannot be easily separated for recycling operations. As a consequence, after several cycles, the metal is increasingly contaminated. This may change its properties, also entailing a reduction of commercial value.

In many cases, the expected revenue from recovered materials can be so low as to make recycling not economically feasible. In several countries (e.g. Sweden and Canada), laws based on the concepts of EPR are already in place for a number of industrial products. The laws on mandatory EPR or governmental encouragements for a voluntary approach to EPR are producing design changes in products.

Marking of plastics is being widely adopted to favour identification and make recycling easier; to avoid the mixing of materials, the labels on the products can be made with the same resin type or can be molded in. There is the example, among many others, of a company that has halved the number of parts, and reduced to less than 1/3 the number of resins used in the construction of printers. The strategy of the company also includes reduction of the amount of materials used, as well as, development of materials with less environmental impact and more value at end-of-life.

In general, there is a tendency to decrease the number of components and screws, as well as, towards a unification of the materials. To facilitate recycling, in some cases, the use of composites of metal and plastic has been abolished. There is also a tendency to limit the use of toxic materials, more expensive to dispose of legally. For example, lead-free solders and chrome-free metal plates have been developed. A greater use of recycled materials in the production of manufactured goods can be observed; this contributes to developing a growing demand for recycled materials which, thanks to the EPR, are produced in increasing amounts. Quick technological progress makes products obsolete faster.

Many producers are working towards a longer product life and easier maintenance and repairs. Some computer brands are designed for easy replacement of the electronic components that allow upgrading of the equipment and hence performance. The easy



upgradeability of the equipment helps the owner to prevent its early obsolescence, thus, extending its life. Some manufacturers have started refurbishment, when possible, and sales of second-hand parts. In this way, the value of a recovered object is much higher, as compared to the value of the same object considered just as simple recyclable material. At the same time, the energetic costs of complete reprocessing are avoided.

According to the concept of EPR, the commitment of the designers in the creation of products should also entail no penalization of function, structural integrity, safety and durability. Still, according to this concept, negative environmental impacts during other phases of the life cycle in favour of changes that facilitate end-of-life management are to be avoided. Meetings are favoured that involve designers and dismantlers, to allow the former to acquire the knowledge necessary to design in such a way as to facilitate the work of the latter. Of course, responsible behaviour of consumers is always of the utmost importance, and reducing waste production at source remains the first choice for the environment. The favourable influence that recycling, repair and reuse activities may have on job creation, in addition to diverting materials from landfills, is beyond the scope of this manuscript. Nevertheless, two interesting readings are suggested about this subject.<sup>30,31</sup>

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