Early Undergraduate Research Experience using Affinity Research Groups for Hispanic Engineering Students

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Abstract

Affinity Research Groups (ARG) is a cooperative learning approach to provide students with structured tasks and activities to strengthen their skills, promoting the success of team members. ARG was used by a group of Hispanic undergraduate engineering students at the Polytechnic University of Puerto Rico's Plasma Engineering Laboratory. The students were provided with training in research, plasma physics, and programming to work in research projects assigned by the faculty members to subgroups of students. The students were required to develop experimental or simulation work as required by the projects, and to present their results in undergraduate research fori. The objective of the project was to study the effect of applying the ARG methodology to students in an early stage of their academic career in terms of engagement, interest, self-reliance, self-belonging, and cognitive factors. Results show a positive change in some of the measured variables and negative change in others.

keywords: Affinity Research Groups, early research experience, STEM education.

Introduction

This work reports the application of the Affinity Research Group (ARG) model to a group of hispanic engineering students participating in a one-year research project in Plasma Physics and Engineering, at the Plasma Engineering Laboratory of Polytechnic university of Puerto Rico. The group named themselves CUSPS (Caribbean Undergraduate Students in Plasma Science). ARG model[9,8] is an innovative way to involve students in research and other activities. ARG bases its effectiveness in the application of methodic and structured activities that develop students skills to make them more effective in research, as well as academic and extra-academic activities, while fostering their leadership and success[12,10]. The benefits of undergraduate research includes an increase in student's confidence with respect to: a) Their ability to do research; b) Their professional self-image; c) Their skill in presenting and defending research. It also provided a venue for: a) Establishing a mentoring relationship with faculty; b) Enhancing peer and professional collegiality. The heart of the ARG (Affinity Research Group) method is the development of skills that results in a highly effective research team where faculty mentors and students enjoy an environment designed to let each member flourish. The theory behind the model is based on two social

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psychological theories: a) *Cooperative Learning* and b) *Situated learning.*[8]ARG model adopts three core values: a) Student success, b) Cooperation, c) Excellence.

Thus, this article examines the effect of a one-year research experience using ARG on the students perceived *self-reliance*, *self-belonging* to the group and engineering community, career and research *engagement*, *interest* in research and STEM and *cognitive factors* affecting their learning. The program also allowed to test the effectiveness of the research experience on *retention* and *persistence* of Hispanic engineering student.

The program was designed to provide: a) Factors influential in the retention and persistence of minority students in STEM[5]; b) Active learning experiences through activities integrated in the higher education classroom[4,11]; c) Allowing students to experience research to provide them with the opportunity to engage on learning processes that enable the creation of the analytical skills required to solve problems in the real-world.[1]

Methodology

The project targeted students of second and third year of in all disciplines of engineering. A series of activities were designed under the framework of ARG to provide different skills to the students. The activities were the following: 1) Selection of the students. 2) ARG Orientation. 3) Pre-evaluation survey. 4) Training of the Students. 5) Assignment of the research projects. 6) Research Work. 7) Preparation of Presentation/Poster. 8) Oral/Poster Presentations. 9) Post-evaluation Survey.

Selection of the students The selection of the student took into account various factors to identify students on risk of not finishing their degree. The main factors for the selection were: a) Economic need as evidenced by the FAFSA data; b) Preference was given to students from the public high school (higher risk of dropping from college); c) First generation in college; d) Little experience in research; e) Increase the number of women that study engineering; f) The number of approved physic courses. Three groups were defined:

1. CUSPS 1, year 1 of the project, GPA was considered as a *non determinant* factor to select the student. The ARG model was applied with little rigorousness.
2. CUSPS 2, year 2 of the project, GPA was *not considered* at all as a factor except for the pre selection of candidates to be interviewed. The ARG model was applied rigorously.
3. CUSPS 3, year 3 of the project, GPA *was determinant* in the selection of participants in the program. The ARG model was applied rigorously.

Twelve (12) students were selected for CUSPS 1, Eleven (11) for CUSPS 2, and twenty (20) for CUSPS 3 for a total of 43 participant for the whole project.

ARG Orientation An initial orientation on the ARG methodology was imparted to the selected students. Students were introduced to technics for skill learning, problem solving and idea prioritization: a) *Jigsaw* dissemination and learning[3]; b) *Brainstorming* for idea generation; c) *Nominal group techniques* for idea prioritization. Basic information about the research projects to be carried out during the year was also provided.

Pre-Evaluation Survey A 23 questions survey was administered to the participant students to capture their perception on the factors under study.[2] The questions measured the categories: a) *Self-reliance*. b) *Interest*. c) *Self-belonging*. d) *Engagement*. e) *Cognitive Factors*. f) *Evaluation of the Experience*.

Training of the Students To bring the students to the level of knowledge required the research projects, one trimester (12 weeks) was spent providing training in: a) *Plasma Physics*; b) *Matlab* programming for both simulation and data acquisition; c) Practical *experimental work* in the laboratory. The following strategies were used:[7] a) Establishing clear objectives of the training; b) Establishing relevance of materials; c) Providing concrete and abstract information in every topic; d) Active learning; e) Cooperative learning; f) Challenging/fair tests; g) Let know that faculty cares about students' learning.

Research Work Research projects were defined by the faculty members based on scientific relevance, difficulty, and knowledge required. Definition of the experimental work included tasks such as design of the experiment, additional training on the measurement equipment to be used, preparation of the software to be used for data collection, definition of the data files to be collected and, of course, the actual experimental work. Simulation work included tasks such as design of simulation experiment to be performed, verification of the software accuracy and correctness by selected manual calculation, discussion of preliminary results, and evaluation of results.

Preparation of Presentation/Poster Providing the students with writing skills[6] needed to face the challenge of writing a research paper and perform a research presentation/poster, the methodology was the following: a) *Progress presentations*. b) *Technical writing workshops*. c) *Rehearsal sessions*.

Post Evaluation Survey A second survey of 23 questions was administered to the students in the program to assess their perception of the experience after the fact. Questions in this survey loosely match the questions in the Pre Evaluation Survey.

Results

This section focus on three of the evaluation instruments used during this project. The pre and post evaluation survey, the faculty outcome evaluation survey, and the GPA evaluation.

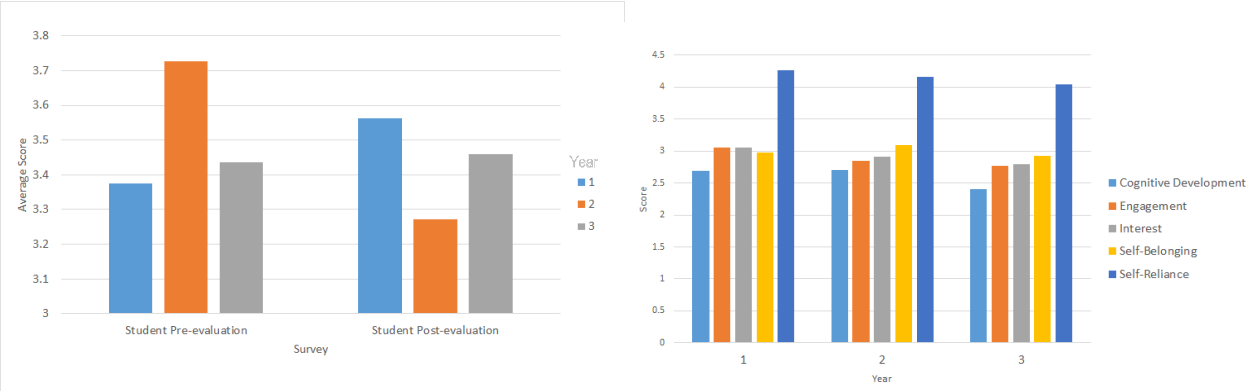
Pre-Evaluation Survey and Post-Evaluation Survey

Students were administered a Pre-Evaluation Survey and Post-Evaluation Survey at the beginning and end of the one-year research experience to assess their perception of their own capacity toward the variables selected as outcomes of the study. Each of the questions of these surveys was mapped to one of the outcomes to be evaluated in the project. Each question was assigned a scored in scale 1 to 5, 1 being poor or in total disagreement and 5, excellent or in total agreement. The average score results of these surveys for the three-year project are shown in Figure 1a. The average score is an indication of their perception of regarding their own Self-reliance, Interest, Self-belonging, Engagement, and Cognitive Factors.

Figure 1a shows that CUSPS 1 and 3 students experimented a boost in their self image represented by the increase in the average score from the pre-evaluation survey to the post-evaluation survey. CUSPS 2 students, however, experimented a descend in their self image from the pre to the post. Notice that also, CUSPS 2 student scored the highest average score in the pre-evaluation survey, and the lowest in the post-evaluation survey. Their expectations were high, but their results were not so satisfactory for them.

Faculty Outcome Evaluation Survey

The Faculty Outcome Evaluation Survey was completed by the faculty members in the project and interacting daily with the students, at the end of the research experience. The rationale is to provide



(a) Average Scores for Pre-Evaluation and Post-Evaluation Surveys by year

(b) Results of the Outcome Criteria Survey completed by Faculty at the end of the one-year experience

Figure 1

a measure of the student performance in relation to the outcomes of the project, from the faculty point of view. The results (Figure 1b) indicate that the most gainful feature of the experience from the faculty point of view was student's *self-reliance*. The lowest score was for *cognitive gain*, (also negatively perceived in the pre- and post- evaluations).

GPA

Finally, the GPA of the students participating of the project was monitored also to compare to general population. Table 1 shows the average cummulative GPA at the beginning of the one-year experience, at the end of the experience and its percent of change, as well as the percent of change of the same cohorts of the general population of students in engineering. The participants cumulative average GPA for CUSPS 1 decreased by 5%, compared to -1.09% for the general population. For CUSPS 2 (GPA not taken into account for selection) the cumulative average GPA decreased 2%, compared to 0.81% for the general population. For CUSPS 3 the cumulative average GPA decreased 6%, compared to a 1.03% decrease for the general population.

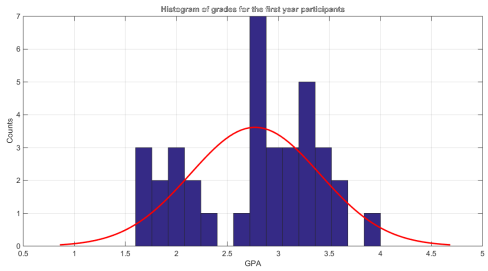
Table 1: GPA Effect

Year	$GPA_{initial}$	GPA_{Final}	CUSPS % of change	GP % of change
1	3.55	3.34	-5%	-1.09%
2	2.92	2.83	-2%	-0.81%
3	3.46	3.23	-6%	-1.03%

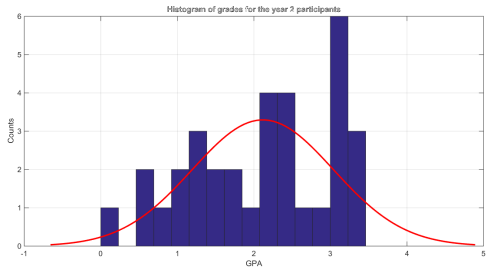
$GPA_{initial}$: GPA at the beginning of the experience, GPA_{Final}: GPA at the end of the experience
CUSPS: Students in the ARG group, GP: General Population of engineering students

Figures 2a to 2d show the distribution of the average GPA per trimester of each year of the project, and for the whole project.

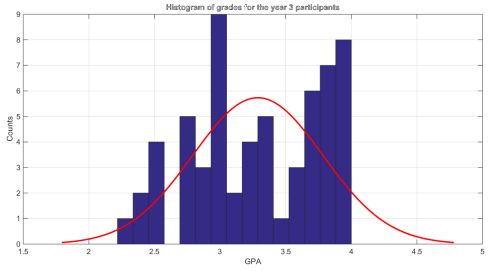
The cumulative GPA of the CUSPS 1 and CUSPS 2 students (CUSPS 3 data is not yet available) at the end (Figure 3a) of the experience was compared to their cumulative GPA one year later (Figure 3b) showing a little increase in average GPA one year later, contrary to the general population tendency. The average GPA at the end of the experience was 3.0943, while one year later the same figure is 3.1045, representing an increase of the 3.21%, contrasting with the drop in the general population average GPA for the same period which was -0.97%.



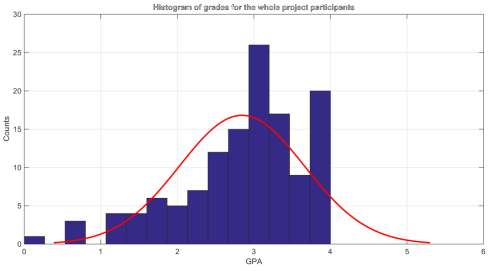
(a) Histogram of GPAs per trimester for CUSPS 1. $\mu = 2.7711$, $\sigma = 0.6351$



(b) Histogram of GPAs per trimester for CUSPS 2. $\mu = 2.1164$, $\sigma = 0.9215$

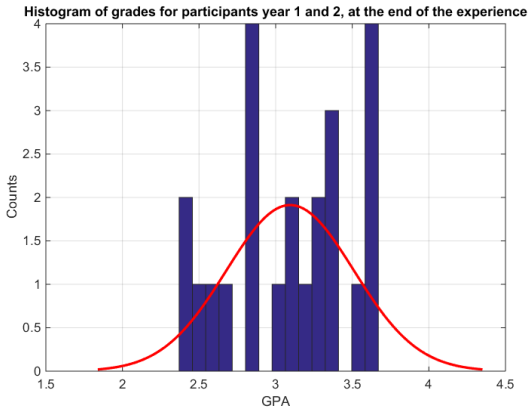


(c) Histogram of GPAs per trimester for CUSPS 3. $\mu = 3.2873$, $\sigma = 0.4960$

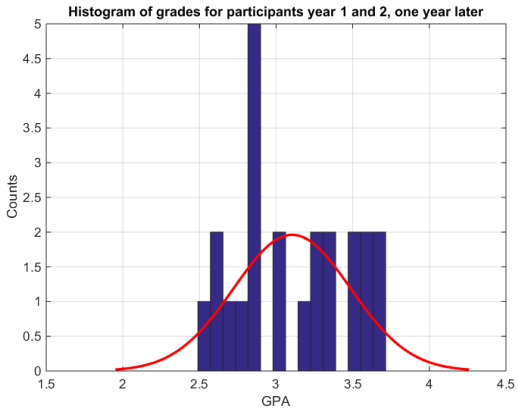


(d) Histogram of GPAs per trimester for the whole project. $\mu = 2.8437$, $\sigma = 0.8161$

Figure 2



(a) Cumulative GPA for CUSPS 1 and CUSPS 2, at the end of the experience. $\mu = 3.0943$, $\sigma = 0.4157$



(b) Cumulative GPA for CUSPS 1 and CUSPS 2, one year later. $\mu = 3.1045$, $\sigma = 0.3819$

Figure 3

Conclusions

Participation in the program provided the students with a set of skills not provided during regular course work. Performing research work, writing a paper/poster and presenting it, significantly developed their self confidence. The participation in undergraduate research conferences gave them the opportunity to interact with scientists and engineers working in diverse fields, meet students from all over the country doing similar work, and discover that they were able to do excellent research. The one-year research experience however, had an impact on their academic performance. The average GPA of all the groups had a descend during the one-year experience. However, one year later CUSPS 1 and 2 groups (data not yet available for CUSPS 3) obtained a slight increase

in average cumulative GPA, contrary to general population tendency to decrease.

Students with moderate academic performance (CUSPS 1) highly benefited from the experience, since it gave them the opportunity to discovering their own abilities and potentialities. CUSPS 1 group best took advantage of the opportunity, finding focus in their objectives both short and long term. Students with lower academic performance (CUSPS 2) had an adverse average result in their self image after the experience. These students entered the program with high expectations, but the workload demands lowered their own self image. Students with good academic performance (CUSPS 3) also benefited greatly from the experience. However, the improvement in their self image was not as large as for students with moderate performance. This results suggest that when using an undergraduate research experience to motivate low income students, at risk of not finishing their career, it is most beneficial for students with moderate academic performance. Other factors may have influence in this result.

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