A Participatory, Outcome-Based Teaching & Learning (OBTL) Tool for Improving Science Communication Skills Among Filipino Engineering Students

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***Abstract*— As the demands in the workplace and industry evolve, engineering education needs to similarly evolve towards 'soft-engineering' – a balance of technical and non-technical training. In addition to gaining more "human" skills, fresh graduates also need to cope-up with the evolving and expanding interdisciplinary changes in the field, a feat that may be difficult to achieve, especially in developing countries. A recent trend in teaching engineering in the Philippines is Outcome-Based Teaching and Learning (OBTL) where the first set of OBTL portfolios were launched in 2009 at the Technological Institute of the Philippines (TIP). In this report, we describe our 'Community-of-Learners' Game Strategy (COL-GS), an innovative OBTL portfolio piloted at TIP-Department of Electronics Engineering (ECE). It is aimed at exposing students to frontier technologies relevant to the ECE while improving public speaking and other non-technical skills. COL-GS utilizes the principle of student-empowered learning to enhance science presentation and critical thinking skills. In this scheme, the ECE students were given the task to study and present in class the latest international, ISI papers on selected topics in the fields of: a) biomedical and bioengineering, b) telemedicine/E-health and c) space engineering and exploration. This participatory teaching concept is implemented in a game format. After each presentation, the student receives comments and is scored by the board of judges and audience/community through SMS voting. As an OBTL tool, COL-GS provides the advantage of rapid feedback using the 'Toastmasters-inspired' Assessment Tasks (ATs) and a platform to reward 'good' performers at the end of each session to motivate the students to improve their presentation skills. Likert Analysis of a 25-item Self-Reflection Questionnaire (SRQ) administered to the 37 undergraduate ECE students indicate that COL-GS may have affected the outcomes in the following order: Communication Skills > Social and Ethical Responsibility > Productivity > Professional Competence > Critical Thinking and Problem Solving Lifelong Learning > Interpersonal Skills. We also observed innovative initiatives from the students who were given freehand in organizing the seminars. Examples of innovations include the playing of music, creation of logos for each team, and filming of attention-grabbing introductory videos with special effects. Over the traditional classroom activity, we believe, COL-GS is a particularly interesting case for OBTL as it is not only focused on attaining the desired outcomes (or skills end points) but also puts due attention to the learning and motivational dynamics while expanding the knowledge frontiers of students.**

Keywords*— *OBTL; participatory learning, games in classrooms, lifelong skills; public speaking; engineering education

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I. INTRODUCTION

It has been a tradition for engineering schools to focus almost entirely on technical skills leaving behind under-developed competences in non-technical attributes, such as communication, team work, life-long learning and even management skills.

As the industry evolves it is imperative for engineering education to also change as a result. The engineering profession is now getting "softer" and new graduates are expected to possess a wider range of skills above their technical acumen. Modern engineers must also be capable of coping with rapid cross-fertilization of the profession by diverse technological global trends, such as biotechnology, material science, nanotechnology, etc.

To provide more opportunities for students to develop these critical attributes, outcomes-based education (OBE) was proposed and has now become widespread as an instrument to enhance teaching and learning. Initially coined by Spady [1],

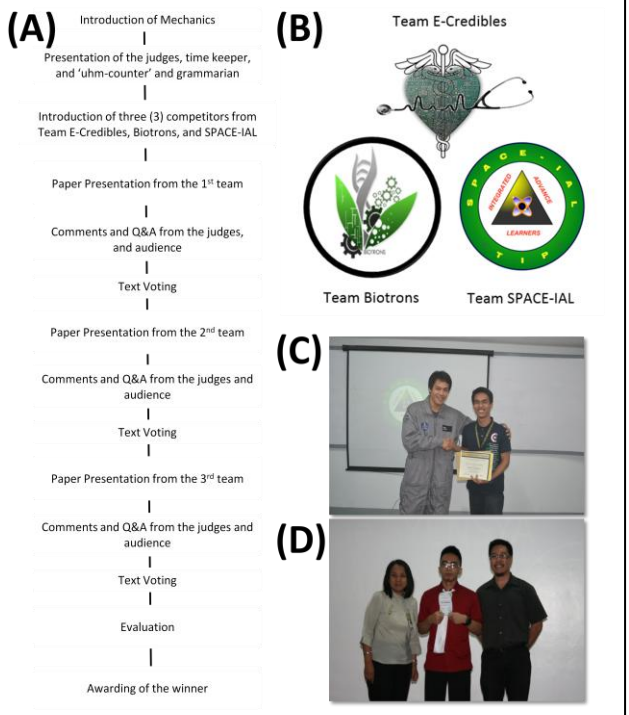

Fig. 1. Activities during the seminar class. (A) COL-GS activity flow. (B) Creative logos designed by the students for the three competing groups. (C) A winning student in the topic of space communication who gets an award and photo opportunity with a Filipino representative from the Florida Space Camp and (D) the Best Student Presenter during finale competition.

OBE "clearly focuses and organizes an educational system around what is essential for all students to be able to do successfully at the end of their learning experiences". Its origins can be traced back in the 60s when schools in the US were criticized for producing students who were ill-equipped with the necessary competencies [2, 3].

Within an OBE regime, teaching and learning approaches (OBTLs) demand more emphasis on learning outcomes: tasks and competencies that students are able demonstrate, rather than on the learning process itself [4]. OBTL, moreover, aims to cultivate a spirit of lifelong learning among students [5].

The Philippines' Commission on Higher Education adopted in 2008 an OBE agenda for engineering, however, its widespread implementation failed to progress. By far, the only Philippine learning institution where OBTL is being widely established is with the Technological Institute of the Philippines (TIP). Revisions in its curricula and teaching approaches started in 2009, and total implementation of OBTL was achieved by 2010 its two campuses, Manila and Quezon City [6].

While OBTL as a framework of pedagogy is relatively new and still evolving in the country, in this paper, we report an innovative teaching and learning activity (TLA) designed to improve the communication skills of our engineering students. We transformed an undergraduate seminars class to one that is student-led and comprehensive in topical coverage while considering lifelong learning. Its strong feature is the unique combination of participatory learning and games, which we term in this report as 'Community-of-Learners' Gaming Strategy (COL-GS). COL-GS adopts Toastmasters-inspired ATs and uses SMS technology in student performance evaluation adding a layer of excitement to the whole learning process of our students.

Student survey responses revealed high levels of satisfaction for the course together with the perceived amount of new information learned. Students commented positively on the discussions and the seminar format. COL-GS is widely applicable to teaching any advanced undergraduate topic that needs to cover vast amount of information while appealing to students and inculcating life-long learning outcomes.

II. METHODS

A. *Subjects*

The subjects of this study were 4th year undergraduate TIP students from the Department of Electronics Engineering (ECE) during the seminars class of the 2nd semester, Fiscal Year 2013-2014. The students were randomized and assigned to three groups representing the topics, biomedical engineering and bioengineering; telemedicine/E-health; and space engineering and exploration. Topic assignment was determined by drawing of lots.

B. *Orientation and expectation settings*

At the start of the class, the students were given an overview of OBTL. The desired skills and outcomes were articulated in consideration of Intended Learning Outcomes and Institutional-Intended Learning Outcomes (Table I). The mechanics and rules of COL-GS were also discussed. Lectures were conducted on how to effectively deliver a scientific paper and how to best answer during the Q&A portion of the conference. This was intended to help the students start learning new skills in oral paper presentation. Reflections on the method of presentation were done together with the class.

C. *COL-GS and Feedback Mechanism*

The flow of COL-GS is shown in Figure 1. The feedback mechanism comprised of comments and scores from the board of judges (60% of the final score) and the audience (40% of the final score). Critical evaluation was focused on delivery (D), content (C) and impact (I) of the student presentation using a scale of 1-5 (5 as the highest score). Audience SMS votes from the competing groups and guests were recorded. It should be noted that SMS votes coming from unregistered text voters were disregarded by the official scorekeeper. SMS voting was done within 30 s upon the signal by the facilitator using the format: D (score) C (score) I (score), for the quality of delivery, content and impact.

At the end of the three presentations, the student garnering the highest score wins. From the set of winners, the top-scoring representative will advance to the finale. During the finale, the students representing the three topical groups will compete against each other. Judges who will be invited during the finale include top local experts in the field and faculty of the English Department. Trophies and commendation were given to the 'Best Student Presenter" and "Best Group". Choice for the "Best Group" is based on the average scores of the students from the group.

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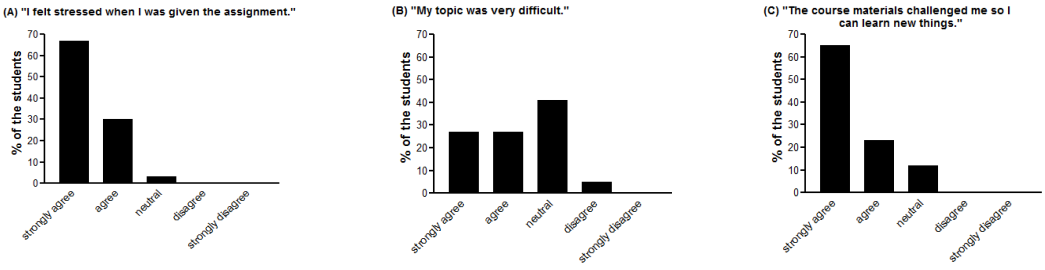

Fig. 2 (A-C). How the students initially perceived the challenging learning task assignments given to them. Topics were assigned based on field and impact factor rating of the journals; 1-5, Likert scale segment.

D. Instrument of Analysis

A 25-item SRQ was developed to measure the OBTL outcomes using the 5-point Likert scale. Responses under each item consist of 'strongly agree', 'agree', 'neutral', 'disagree', and 'strongly disagree'. In scoring, 5 points was assigned to answer 'strongly agree' at positive items, and 1 point was assigned to answer 'strongly agree' at negative meaning items. Higher values correspond to a stronger impact of the TLA on a particular attribute. The SRQ was administered to the students and it took approx. 10 minutes to be completed. Data were inputted in Excel and graphs were made using GraphPad Prism.

III. RESULTS AND DISCUSSIONS

Although teachers are often clear about their teaching objectives, at times they fail to communicate the learning objectives to their students. Under OBTL, it is a pre-requisite for the teacher to articulate the skills and learning outcomes prior to designing and implementing the TLAs. At the start of our class, we were particular in communicating the desired learning outcomes to our students- the core values embodied in school' IILOs.

The next step was the design of an appropriate TLA. For learning to be enjoyable, instead of the traditional "chalk and board" classroom method, we designed a TLA that was more student-centered and participatory. We termed the activity COL-GS, a tool that empowers students to learn and share their knowledge to others for their transformative development. Aside from polishing science presentation skills, the students were also given the task to evaluate the performance of their peers.

Student response to novel and challenging assignments. At the beginning of the course, we briefed the students that they will be present topics in front of the class and the panel expert of judges on the special topics from three 'frontier fields'. We emphasized that as ECE students, they were required to give technical presentations that can be understood by engineers and also appreciated by the non-engineers. The frontier fields were biomedical engineering and bioengineering (BE); telemedicine/E-health (EH); and space engineering and exploration (SE). These areas were chosen to introduce our students to the emerging cross-disciplines of ECE. These fields are particularly relevant to the proposed R&D cooperation between the school and a government hospital on space medicine and telemedicine, and for the establishment of a biomedical engineering track under our ECE Department.

The class was divided into 3 groups based on the topics. To give a sense of competition, the students were given the task to provide a name for their group and make their own "creative" logos. During the subsequent meetings, the students presented the names and logos for their groups; these were: "Biotrons", "E-credibles" and "Space-cial" for BE, EH and SE, respectively (Fig. 1B).

During the 1st week, the students were also requested to perform a comprehensive journal search for international, ISI-papers published during the last 3 years. From a list of 3 topics submitted, the final seminar papers were approved by the teacher putting into mind the diversity of possible ECE-related topics that we wish to cover in class.

The students were also encouraged to correspond to the primary authors of the scientific papers that they were assigned with. Apart from boosting self-confidence, this tasks hope to help initiate to networks for future post-graduate activities. The students were required to show proof of this activity.

It was the first time the students were to study and present such diverse topics in public. We found that 54% of the class initially perceived the topic to be difficult (Fig. 2A). This may just be an immediate reaction as the task was perceived to be stressful to 34% of the students (Fig. 2B). In anticipation to the pressures, we motivated our students during the orientation regarding the course expectations and how to cope with the volume of assignments. From the survey, majority of the students viewed their homework, regardless of its difficulty, as an intellectual challenge rather than as drudgery (Figure 2C). Interestingly, the pattern of the latter was similar to that of students who felt stressed when the topics were first assigned to them.

Impact on communication skills and on the other TIP graduate attributes. The 2012 Millennial Branding Study that analyzed a data pool from over 100,000 US companies indicate information on student employment gap and character traits being actively sought by companies. From the study, the following trend in attributes for entry-level technical position emerged: 98 % communication skills and 92 % teamwork skills [7, 8].

On the same note, various US universities have addressed similar gaps in earlier recommendations pushing for a reorganization of the education system in order to provide students, aside with a college diploma, "intentional" lifelong learning that would help make them more competitive in the real word [5, 9].

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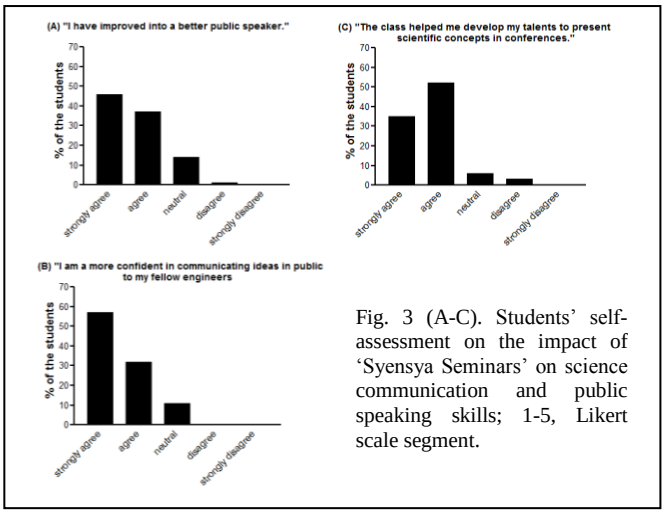

Fig. 3 (A-C). Students' self-assessment on the impact of 'Syensya Seminars' on science communication and public speaking skills; 1-5, Likert scale segment.

Under the ABET Engineering Criteria 2000, engineering schools, such as TIP, are tasked to demonstrate that their graduates are achieving a set of specified learning outcomes [10]. What then are these outcomes? In our activity, we aligned our OBTL portfolio according to the Institutional-Intended Learning Outcomes (IILOs) of TIP which include the following: professional (technical) competence, critical thinking and problem solving skills, communication skills, lifelong learning, social and ethical responsibility and interpersonal skills. Of note, the IILOs are similar to the ABET competencies ranked by graduates of 11 engineering programs in a large public university in the Midwest. The top cluster of competencies include teamwork, communication, data analysis [11].

In an attempt to identify which of the IILO that COL-GS has greater impact we developed a 25-point SQR and determined Likert Scales of the perceived benefits and reactions from the students.

As a rapid assessment, we clustered SRQ items according to their possible associations to a specific graduate attribute. Clustering of SQRs that, directly or indirectly, address a specific IILO was derived from a consensus with independent panel. A question may be associated with IILO directly, such as with the phrase: "*I feel I have improved into a better public speaker*" and attribute: "communication skills". Or, it may be indirect, as in the case of the phrase: "*I feel happy imparting new knowledge to my peers*" and attribute "social and ethical responsibility".

Based on our preliminary analysis, this OBTL activity may have made an impact the following TIP graduate attributes according the following order: Communication Skills > Social and Ethical Responsibility > Productivity > Professional Competence > Critical Thinking and Problem Solving > Lifelong Learning > Interpersonal Skills (Table I). The impact on these attributes, despite lacking an in-depth qualitative analysis, may be amenable to change depending on the general profile of the students.

Improved communication skills were apparently the most affected attribute among our students since this was the goal in mind for creating this OBTL portfolio (Fig. 3 A-C). It is a general observation by the faculty that our students are typically 'shy' and show a 'lack of confidence' during public speaking engagements, such as the thesis and proposal defense. Whether COL-GS has an impact on improving thesis defense and presentation skills of the student remain to be explored.

What surprised us was that this attribute is also closely linked to the student's concept of 'social and ethical responsibility'. This attribute might be consequential from the participatory learning where students assume responsibilities as co-teachers. Such action dynamics elegantly captures the often-referenced quote of Dr. Frank Oppenheimer: "*the best way to learn is to teach*".

Employment of a participatory learning paradigm. Participatory learning is an adaptive teaching strategy that enables various individuals to learn, work and act together in a co-operative manner. Its principle is different from the traditional top-down relationship between teacher and student, where the former is the knowledge source and the latter is a mere recipient of learning. With participatory learning, our 'community of learners' becomes co-responsible for the direction and dynamics of the learning process. The process is akin to being 'organic' and participatory as it encourages students and teachers alike, to engage in cycles of teaching and learning, co-analysis, reflection and evaluation [12].

To facilitate the process, we used mobile devices to provide rapid feedback *via* SMS. We put in place 'Toastmasters' instruments, e.g. grammarians, time keepers, 'uhm'-counters. These are critical elements in our participatory learning 'playground' as they help enhance collaboration, connect students with their peers and teachers, and mold the self-concept.

On the whole, the range of the average Likert mean scores was 3.6 + 1.0 to 4.3 + 0.1 for the 7 IILOs implies that the students' feedback on the OBTL were largely positive.

Creation of an environment conducive to learning and the display of creativity. The incorporation of the 'American Idol'-style games, and the Toastmasters' evaluation techniques of 'kiss-kick-kiss' were among the strategies employed to create a warm and welcoming environment conducive to learning and which facilitated social and academic growth of the participants. Every idea was welcomed, no one was ridiculed even if mistakes were committed (e.g. wrong English grammar,

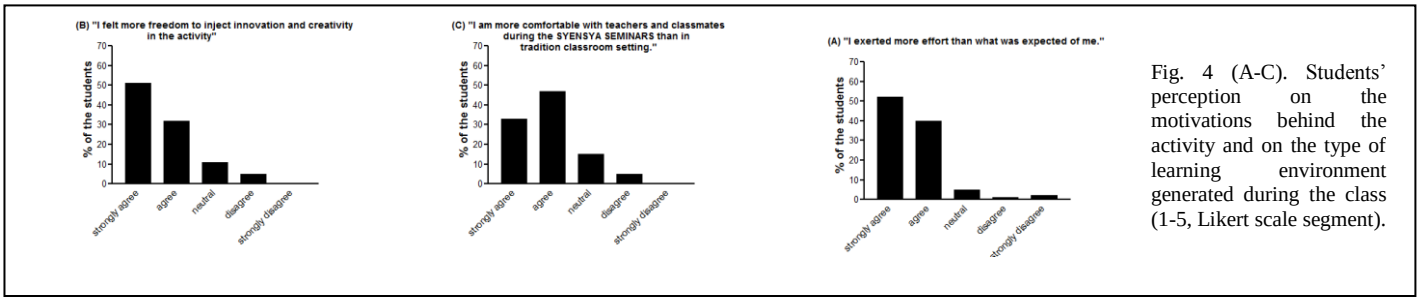

Fig. 4 (A-C). Students' perception on the motivations behind the activity and on the type of learning environment generated during the class (1-5, Likert scale segment).

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Table I. Assessment of OBTL skills and attributes of the students based on the Institutional Intended learning Outcomes (IILO).

GRADUATE ATTRIBUTES	IILO	EXPECTED STUDENT OUTCOMES	LIKERT SCORE	RANK
Professional Competence	**Demonstrate** understanding and mastery of the fundamental knowledge and skills required for effective professional practice in the field of specialization.	To have thorough understanding of the novel applications in BE, EH and SE requiring mastery of fundamental ECE principles	**4.0 ± 1.1**	**4**
Critical Thinking and Problem Solving Skills	**Exercise** critical and creative thinking in providing solutions to discipline-related problems.	*Student presentor*: To possess critical evaluation skills of the chosen scientific paper and develop a presentation strategy *Student audience*: To formulate 'difficult' technical questions by competing groups to challenge the knowledge of the speaker	**3.7 ± 0.9**	**5**
Communication Skills	**Apply** effective communication skills, both orally and in writing, using the English language.	Effective technical 'story telling' of the paper within 20-mins Minimal buckling and annoying filler words (i.e. uhms, "basically", "you know", etc.) Employment of non-verbal cues Effective powerpoint presentations	**4.3 ± 0.1**	**1**
Lifelong Learning	**Utilize** lifelong learning skills in pursuit of personal development and excellence in professional practice	Communication skills Teamwork Passion for learning Winning mindset	**3.7 ± 0.9**	**6**
Social and Ethical Responsibility	**Hold** personal values and beliefs as ethical professional consistent with Filipino family values, industry-desired values and global citizen values.	Optimism about the future Care for other people Friendship and friendliness	**4.2 ± 0.1**	**2**
Productivity	**Contribute** to nation-building and national development through application of new technology	Democratic process of evaluation of peers ("having everybody's opinion matter) using SMS More expansive view of ECE in nation-building Innovation and creativity	**4.0 ± 0.7**	**3**
Interpersonal Skills	**Work** effectively in multi-disciplinary and multicultural teams	Diplomatic solutions for handling difficult questions Linking with top international scientists and experts	**3.6 ± 1.0**	**7**

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etc.). Thus, none of our students appear fearful of being reprimanded or put down. Of the students surveyed, 90% exerted more effort in the course than what was expected of them by their teachers (Fig. 4A), and 82% introduced innovative strategies to make their presentation more engaging (Fig. 4B).

All in all, our COL-GS was successful in creating a non-threatening and enjoyable atmosphere of learning despite the seemingly 'harsh' and expansive breadth of tasks given to the students. Eighty % of the students even reported to have experienced comfortable relationship between their peers and teachers during the class (Fig. 4C).

Diversification of career goal of our students. Notably, COL-GS introduced a paradigm-shift among our students on the role of ECE in nation-building and global S&T advancement. In our prior discussions, our students' career option was (traditionally) limited to passing the board exams and applying for jobs in the telecommunications industry. With the knowledge on the frontier sciences and linkages created with scientists from different countries, our students realized the gamut of opportunities available when they graduate (Fig. 5A-B). More than that, 40% of the students were also inspired to consider pursuing further studies (Fig. 5C) and aspire to becoming scientists and/or professors who will take up roles in advancing the field in the Philippines.

All in all, as our students acted as discussion leaders for the assigned 'frontier topics in ECE', while the instructors act as facilitators, and the rest of the class as evaluators and learners. Our student survey responses revealed high levels of satisfaction for the course and with the instructors despite the amount of task involved on the part of the students and the wide coverage of topics. Students also commented positively on the discussions and raised several technical questions on the topics indicative of their critical thinking and interest.

Appealing to students who all played an active role of student learners and student-teachers, COL-GS will be adopted by other engineering departments because of its innovative educational methods and ease in implementation as an OBTL portfolio for undergraduate seminars.

IV. CONCLUDING REMARKS

The success of this OBTL portfolio first, depends on identifying what our students had to learn and the skills that they needed to acquire and subsequently, fashioning TLAs according to those identified outcome goals; second, it was also important to have a systems view of OBTL, that is, one should not lose sight of the higher institutional goals (we refer here, in this case, the TIP's Graduate Attributes and IILO); third, as student's progress was based on demonstrated achievement it was crucial to employ a rapid and non-threatening mechanism of feedback based on validated ATs; and lastly, multiple instructional and teaching strategies need to be implemented to make the OBTL guided-course fun and memorable for the students.

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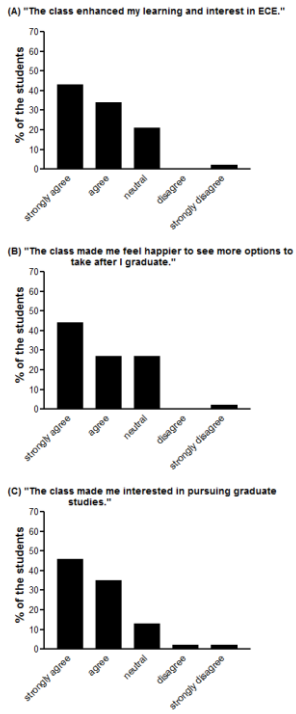

Figure 5 (A-C). Influence of COG-GS on students' perception on the field of electronics engineering and its possible impact on their future career options; 1-5, Likert scale segment.

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