Bootstrapping Research Output with the Education Triad: A Plan

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Abstract– Engineering institutions that concentrate mostly on teaching face an uphill battle in their efforts to increase the research output of the faculty. High academic loads, time spent away from research after the PhD, and the lack of mentoring are just some of the many reasons that stand in the way of increasing research output. This paper describes a plan to accelerate the transformation from "teaching" to a "teaching-and-research" institution as measured by number of published journal papers and amount of external funding generated. The transformation is based on two ideas: bootstrapping, and the education triad. Bootstrapping is defined as the technique of starting with existing resources to create something more complex and effective, as in "pulling yourself up by your own bootstraps". The education triad refers to the three central tenets in which education is based, that is, guidance, practice, and feedback. The first tenet in the triad, "Guidance", takes two forms. First, National Science Foundation (NSF) guidelines for writing proposals are used as the basis for the effort. Second, a research program created by the author, is inserted as a guidance example within a presentation of the NSF guidelines to faculty. "Practice" is provided by asking the faculty to erase the given example and substitute it with their own research program. "Feedback" is provided by the same faculty, some of whom have already started transitioning successfully to teaching-and-research, who meet regularly to act as a "Review Panel" that observes and criticizes the research programs created by their colleagues. The focus of the effort is not on immediately writing a proposal but on creating a structure that leads to becoming a scholar and to successful proposal writing. The structure includes writing good research questions, identifying the data that is required to answer the research questions, thinking of potential paper titles that would result from the effort, writing research objectives in a form acceptable to NSF, and writing statements of "intellectual merit" and "broader impacts", also required by NSF, that express why the research program is worthy of external funding. The example provided to the faculty incorporates all of these. The paper includes details of the NSF guidelines as well as the research program that was created for the example. Ethics is also covered as part of the NSF guidelines to protect the confidentiality and ownership of the ideas presented by colleagues during the "Review Panel" sessions.

Keywords—bootstrapping, research, transformation, education triad.

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Abstract**– *Engineering institutions that concentrate mostly on teaching face an uphill battle in their efforts to increase the research output of the faculty. High academic loads, time spent away from research after the PhD, and the lack of mentoring are just some of the many reasons that stand in the way of increasing research output. This paper describes a plan to accelerate the transformation from "teaching" to a "teaching-and-research" institution as measured by number of published journal papers and amount of external funding generated. The transformation is based on two ideas: bootstrapping, and the education triad. Bootstrapping is defined as the technique of starting with existing resources to create something more complex and effective, as in "pulling yourself up by your own bootstraps". The education triad refers to the three central tenets in which education is based, that is, guidance, practice, and feedback. The first tenet in the triad, "Guidance", takes two forms. First, National Science Foundation (NSF) guidelines for writing proposals are used as the basis for the effort. Second, a research program created by the author, is inserted as a guidance example within a presentation of the NSF guidelines to faculty. "Practice" is provided by asking the faculty to erase the given example and substitute it with their own research program. "Feedback" is provided by the same faculty, some of whom have already started transitioning successfully to teaching-and-research, who meet regularly to act as a "Review Panel" that observes and criticizes the research programs created by their colleagues. The focus of the effort is not on immediately writing a proposal but on creating a structure that leads to becoming a scholar and to successful proposal writing. The structure includes writing good research questions, identifying the data that is required to answer the research questions, thinking of potential paper titles that would result from the effort, writing research objectives in a form acceptable to NSF, and writing statements of "intellectual merit" and "broader impacts", also required by NSF, that express why the research program is worthy of external funding. The example provided to the faculty incorporates all of these. The paper includes details of the NSF guidelines as well as the research program that was created for the example. Ethics is also covered as part of the NSF guidelines to protect the confidentiality and ownership of the ideas presented by colleagues during the "Review Panel" sessions.*

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I. Introduction

Engineering institutions that have historically concentrated on teaching, face an uphill battle in their efforts to increase the research output of the faculty. High academic loads, time spent away from research after PhD completion, and the lack of mentoring are just some of the many reasons that stand in the way of increasing research output.

The primary objective of the plan described in this paper is to accelerate the transformation from "teaching" to a "teaching-and-research" institution as measured by number of published journal papers and amount of external funding generated. The transformation is based on two ideas: bootstrapping and the education triad.

"Bootstrapping", included in the title of the paper, is defined by the Oxford dictionary as "the technique of starting with existing resources to create something more complex and effective" [1]. In this case it suggests that the improvements in research output will originate and develop within the faculty group itself.

The term "bootstrapping" has been used in many fields; for example, Dawes [2] coined the term "judgmental bootstrapping" in the 1970's as applied to forecasting models in operations research. In this case it is a regression model that is based on past opinions of experts to try to predict what the experts would forecast into the future in any particular field.

The "Education Triad" in the title of the paper refers to the three central tenets in which education is based, that is, guidance, practice, and feedback [3, 6].

The first tenet in the education triad, "Guidance", takes two forms. First, National Science Foundation (NSF) guidelines for writing proposals are used as the basis for the effort [4, 5]. The guidelines were prepared by Dr. George Hazelrigg who has decades of experience evaluating proposals as a program officer and director for NSF. The principal points of the NSF guidelines are included as citations to provide context to the paper.

In addition to the NSF guidelines, the author created a research program that was inserted as an example in a presentation to the faculty. The example, which is an engineering education research effort, was included interspersed within the presentation of the NSF guidelines at appropriate points. The example is presented below under "Example of Research Program".

The second tenet in the education triad, "Practice", is provided by asking the faculty to erase the given example and substitute it with their own research program.

In *How People Learn* [6], the book that provides the concept of the education triad, and the foundation for the theoretical frameworks used in engineering education research, Bransford, et al, address the concept of "deliberate practice" which "emphasizes the importance of helping students monitor their learning so that they seek feedback and actively evaluate their strategies and current levels of understanding". The

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faculty, who take the role of learners in this effort, must engage in "deliberate practice" while conducting the exercise in order for the bootstrapping operation to work.

The third and final tenet in the education triad, "Feedback", is provided by the same faculty, some of whom have already started transitioning successfully to teaching-and-research. The faculty will meet regularly to act as a "Review Panel" that observes and criticizes the research programs created by their colleagues. The faculty who presents their research program rotates periodically. All the remaining faculty members become part of the review panel. The faculty benefits in two ways: 1. they receive mentoring to improve their respective research programs, and, 2., they get to see other research programs which serve as additional examples.

This effort was started on December 7, 2016 in a presentation to the Mechanical Engineering (ME) faculty at Universidad del Turabo (UT) by the author who is the ME Department Head. The presentation included the NSF guidelines, additional guidance, and an Example Research Program. The "Review Panel" of ME faculty will start meeting periodically in the Spring 2017 semester with the first meeting scheduled for February 15, 2017.

II. Hypothesis

The objective of this research project is to test the hypothesis that, in a predominantly "teaching" institution, research output may be increased by a bootstrap effort; that is, an effort that is carried out by its own faculty members who come together collectively to rise to higher levels of research production. Furthermore, the bootstrap hypothesis is based on education's fundamental triad, e.g., guidance, practice and feedback. The only external element of the effort is in the triad element of "guidance", most of which is based on a presentation by Dr. George Hazelrigg of the National Science Foundation. The "practice" element is conducted gradually by the faculty. It starts by drafting potential research questions that are clear and concise and that lead to the data that is required to answer them. This initial step also includes writing potential titles for papers and drafting research objectives in the form that is appropriate to obtain external funding for research from NSF. This initial step is followed by a more incisive look at the intellectual merit of the research program and the redrafting of the research questions as the faculty attain higher levels of scholarly achievement. The final step is obtaining research funding and writing scholarly papers in journals of high reputation. The "feedback' element is collectively provided throughout the entire process by the entire faculty but is led by the author and other faculty members who have already had some success in research.

III. Education Triad Element #1A: "Guidance" NSF Guidelines

This section primarily includes citations from the NSF guidelines (Ref. 4 unless otherwise noted). The citations are included in the paper to provide context.

The following topics are included in the paper:

- What is research?
- Research Questions
- Caveat on Research Questions
- On becoming a scholar (Groundwork)
- Research Objectives
- Intellectual Merit
- Broader Impacts
- Ethics
- Gradual Build-Up of your Research Program

What is Research?

"Research is defined as the process of finding out something that we (society) do not already know (this excludes library research)".

Elements of Good Research Questions

- *"Good research questions guide and center your research."* [7]
- They point directly at the data that you need to obtain to answer the question.
- They are the basis for writing good research objectives that are primordial in proposals.
- They form the basis for the titles of papers.
- A list of interesting research questions will assist you in recruiting potential students.

Caveat on Research Questions

- *"Do not assume that, because you do not understand an area, no one understands it or that there has been no previous research conducted in the area."*
- *"If you want to get into a new area of research, learn something about the area before you write a proposal."*
- *"Research previous work. Be a scholar."*
- *"Be sure to frame your project appropriately, acknowledging the current limits of knowledge and making clear your contribution to the extension of these limits. Be sure that you include references to the extant work of others. Proposals that include references only to the work of the principal investigator stand a negligible probability of success."*

On becoming a scholar ("erudito")

- *"What is the current state-of-the-art in your field?"*
- *"Who are the top ten researchers?"*
- *"What are they doing right now?"*

- *"What do they consider to be the key research issues?"*
- *"Where do they get their funding?"*
- *"What are the grant opportunities, and how much funding is available?"*

Research Objectives

- *"Fewer than one in ten investigators frames their research in a way that is to their advantage. It should be totally obvious that the most important thing a reviewer wants to know when he or she picks up a proposal is what it's about. Ergo, for NSF, sentence one, of paragraph one, of page one, should begin: 'The research objective of this proposal is...'"*
- *"NSF funds fundamental research so the research objective of the proposed project should be research. There are many words that, to reviewers, mean "not research." These include "develop," "design," "optimize," "control," "manage," and so on. If your statement of your research objective includes one of these words you have just told the reviewers that your objective is not research, and your rating will be lower. Count on it."*
- *"I know of only four ways to state a research objective. If you can think of another, please let me know. The four I know are these:*
  1. *The research objective of this proposal is to test the hypothesis H.*
  2. *The research objective of this proposal is to measure parameter P with accuracy A.*
  3. *The research objective of this proposal is to prove the conjecture C.*
  4. *The research objective of this proposal is to apply method M from disciplinary area D to solve problem P in disciplinary area E." This research integrates knowledge from one disciplinary area into another. To do this often involves the resolution of inconsistencies across the disciplines."*

Intellectual Merit

"The Intellectual Merit is the contribution that your research makes to the knowledge base and how that impacts the field. It includes answering the following questions:

- *What is already known?*
- *What will your research add?*
- *What will this do to enhance or enable research in your or other fields?*
- *Why is your contribution important to your research community?*
- *How will your results be "transformative?"*

Broader Impacts

"The Broader Impact focuses on the benefit to society at large as a result of your research. How will your results be applied? Why would the general public care? Means to benefit society include:

- *Economic/environment/energy/health/safety*
- *Education and training*
- *Providing opportunities for underrepresented groups*
- *Improving research and education infrastructure"*

Ethics

The following statements were included as guidelines for proper ethical conduct:

- Sharing the assignments with the faculty (Review Panel concept) will involve accepting an oath of confidentiality indicating that we will not steal ideas, including the example presented.
- If you like someone's ideas, approach them to collaborate. You may develop additional research questions so that everyone is in a win-win situation regarding authorship of papers and external funding opportunities.
- If you perceive any potential for conflict of interest or another form of a breach of ethics, please inform it ASAP to the Department Head or the Dean to clarify the situation.

Gradual Build-Up of your Research Program

The following final remarks were included as guidelines to the faculty:

- The NSF framework presented here is appropriate for any research program and any funding agency because it focuses on general aspects (research objectives, intellectual merit, broader impacts) and not on specific NSF details (how to use Fastlane, acceptable font size for the proposal, etc.). It is easily adaptable to agencies that are not as stringent as NSF and accept proposals for conducting work other than research, for example, development and/or design.
- Build up your research program gradually. Come up with initial research questions that require minimal funding (only time) for which you can conduct research and write some papers. It will provide a basis for your first winning proposal.

IV. EDUCATION TRIAD ELEMENT #1B: "GUIDANCE" RESEARCH PROGRAM EXAMPLE

This section includes the example research program that was presented to the faculty. The example belongs to the Engineering Education Research field. It is motivated by the low passing rates in the FE Exam in Puerto Rico, which based on the only island-wide official data available to the author [8], was on the order of 30% between 2001-2005. The data includes first-time exam takers as well as repeat takers. The national average passing rate in the USA, including Puerto Rico, is approximately 75% for first-time exam takers.

Example Research Questions

Q1: Are low FE Exam passing rates in Puerto Rico an issue of language or formulation difficulties? (the FE Exam is only available in English)

Q2: Is the issue of low passing rates endemic to all Hispanic populations, including those in the mainland USA?

Q3: Is the difficulty in formulating the problem due to poor conceptual understanding or something else (i.e. lack of practice in formulating problems, time pressures, test anxiety, etc.)?

Q4: Can we create "threshold" problems that will quickly predict the outcome of the FE Exam?

Q5: To the extent that the problem is due to poor conceptual understanding, can certain interventions (concept questions, ranking tasks dealing with concepts, etc.) be used to improve student performance in this area?

Potential papers that may be written and required data

As part of the exercise, the faculty is asked to anticipate the titles of potential papers that may be written as a result of their research. They are also asked to indicate, in general terms, the data that would be required to answer the research questions.

Paper for Q1: "Language or Formulation difficulties?, an FE Exam Experiment in a Hispanic Setting". Abstract accepted in the 2017 ASEE Annual Conference:
Data for Q1 Paper: Already obtained. Students asked to translate an exam problem as well as formulate it.

Paper for Q2: "A Comparison of FE Exam Passing Rates in Hispanic Settings"
Data for Q2 paper: FE Exam passing rates from different Hispanic settings. Potential sources: NCEES, Licensing Boards, HSI universities.

Paper for Q3: "Analysis of potential pitfalls for Hispanic engineers regarding success in passing the FE Exam"
Data for Q3 paper: Add a survey to the problems designed to measure FE Exam performance

Paper for Q4: "Predictors for Passing the FE Exam"
Data for Q4 paper: Requires a study with the alumni who have taken the FE exam. The group must be separated into those who passed the FE Exam and those who did not. Current students will also participate and their future exam results would be monitored to test the hypothesis.

Paper for Q5: "Analysis of interventions designed to improve the probability of passing the FE Exam"
Data for Q5 paper: Try out several interventions with students to test the hypothesis. It could result in more than one paper.

Example Research Objectives

The faculty is asked to turn each of their research questions into a research objective that would be acceptable in an NSF proposal. In this example, the form of all the objectives is the first one listed above by Hazelrigg, e.g., "*The research objective of this proposal is to test hypothesis H*".

Obj. 1A for Q1: To test the hypothesis that language difficulties are preventing students from fully understanding the FE Exam problem; therefore, they are unable to pass it.

Obj. 1B for Q1: If language is not the main problem, test the alternate hypothesis that students have difficulties formulating problems.

Obj. 2 for Q2: To test the hypothesis that the low FE Exam passing rates in Puerto Rico is actually a subset of a bigger issue that is endemic to Hispanic populations in general

Obj. 3 for Q3: To test the hypothesis that difficulties in formulating engineering problems is due to poor conceptual understanding rather than external factors such as test anxiety and time pressures.

Obj. 4 for Q4: To test the hypothesis that "threshold problems" may be identified and/or created that will predict who passes the FE Exam.

Obj. 5 for Q5: To test the hypothesis that students who do not yet have the level to solve "threshold problems" that predict passing the FE Exam, can be trained to reach the desired level through appropriate interventions

Example Intellectual Merit

The following points provide the "intellectual merit" of the example research program:

- If successful, this research program will identify the main causes for low passing rates in the FE Exam in Puerto Rico, it will identify/create threshold problems that will predict the outcome of the exam, and it will use the threshold problems as a basis for providing additional interventions to raise the level of the exam taker.
- This new predictive capability will bring in significant improvements in providing focalized interventions to students at risk of failing the FE Exam.
- This novel aspect has far reaching benefits in engineering education particularly with respect to assessment efforts for ABET Outcome E: an ability to identify, formulate and solve engineering problems.

Example Broader Impacts

The following points provide the "broader impacts" of the example research program:

- If successful, a benefit of this research program is that it will address the underrepresented group of Hispanic engineers, first within the boundaries of Puerto Rico, and potentially within all the Hispanic settings in the mainland USA.
- More licensed professional engineers will be added to the workforce.
- Will lead to training programs to faculty that are based on novel predictive capabilities.
- Will contribute to the educational mission of any university by providing excellence in education as measured by a standardized test (FE Exam) that has high prestige within the engineering community.

V. EDUCATION TRIAD ELEMENT #2: "PRACTICE"

The faculty members were asked to replace the example research program with their own. Emphasis is on developing the structure to create a research program rather than on immediately using this work to obtain external funding. Bransford's concept of "deliberate practice" [6] will be emphasized; that is, the faculty must monitor their learning on how to create the structure of a research program so that "they seek feedback and actively evaluate their strategies and current levels of understanding". It is a crucial component for the bootstrap operation to work. It is also the means to start working on the groundwork that will lead them to become scholars as in, for example, knowing the top researchers in their field, knowing what is important to them in terms of research, and ensuring that they have clearly defined the limits of knowledge so that they can pursue research with a high degree of intellectual merit. Practice will be continuous and the efforts will be checked monthly during the faculty meetings that serve as "Review Panel" sessions.

VI. EDUCATION TRIAD ELEMENT #3: "FEEDBACK"

Feedback, the third component of the triad, will be provided formally during the monthly "Review Panel" session meetings. It will also be provided informally through the casual conversations that take place daily in the university. Both channels, the formal and the informal, are important. This becomes evident it the bootstrapping operation is thought of as an innovation. In the book *Diffusion of Innovations*, the author Everett Rogers [9, page 5] states that diffusion *"is a kind of social change, defined as the process by which alteration occurs in the structure and function of a social system."* Furthermore, diffusion is defined as *"the process by which an innovation is communicated through certain channels over time among the members of a social system."* The four main elements that influence the spread of a new idea are, according to Rogers: the innovation, communication channels, time, and a social system. These four elements are found in every diffusion program. Rogers notes that the informal channel is critical since it has been shown that *"most people depend mainly upon a subjective evaluation of an innovation that is conveyed to them from other individuals like themselves who have previously adopted the innovation."* [9, page 18]. Rogers continues this thought in the same page by stating *"This dependence on the communicated experience of near-peers suggests that the heart of the diffusion process is the modelling and imitation by potential adopters of their network partners who have adopted previously"*.

There are a few faculty members who have adopted, on their own, the structured approach to research presented in this paper. They have been successful writing winning proposals, conducting research, culminating projects, and writing meaningful papers. The author of this paper, for example, was heavily influenced by Dr. George Hazelrigg's presentation in 2009 and used the very same ideas as the basis to win a $4.3 million grant from the US Department of Education (USDE) in 2011 and a $50,000 grant from NSF in 2014. In addition, Rogers' ideas on diffusion of innovations have already been used by the author [10] as the basis to diffuse teaching and learning innovations in the university. All the engineering and physics faculty of the university participated in a Summer Faculty Immersion program through funding from the $4.3M USDE grant that ran between 2011 and 2016. It is positive that the faculty have already experienced the process of diffusing an innovation.

It is expected that the feedback that will be offered by the author and other, experienced members of the faculty, will fulfill the third and final component of the education triad on which this work is based: feedback.

VII. MILESTONES FOR IMPLEMENTATION

Past Meetings

December 7, 2016. The author presented *Research Vision 2020 with an Example* to the Faculty of Mechanical Engineering (ME).

February 15, 2017. The ME faculty conducted the first "Review Panel" meeting. It included one faculty observer from Industrial and Management Engineering and another faculty observer from Civil Engineering who were invited to participate and to provide external feedback to the author. The ME faculty members came to the meeting after having practiced drafting the first set of potential research questions, required data, research objectives in NSF form, and potential paper titles. The feedback was, in general, that research questions required more focus (many were too general); to add "instrumentation required" (to get an idea of the funding required) to the "required data" section that asks the faculty to summarize the data that is needed to answer the research question. The feedback also included the need to redraft the research objective in terms of NSF requirements; and to redraft some potential paper titles that did not quite encompass the research questions. There was a high participation rate and, as expected, the first time that a group of learners were allowed to practice, resulted in a lot of feedback, mostly to line it up with the guidelines provided in the Research Vision 2020 presentation.

Future Meetings

March 15, 2017. The faculty will meet once again to review their research programs after having redrafted them based on the feedback from the Feb. 2017 meeting. The emphasis will be on achieving high-level writing skills, particularly on writing good research questions, potential paper titles, and research objectives that are apt for NSF proposals. The other point that is emphasized is on envisioning the data that is required to answer the research questions, and the necessary instrumentation and equipment to obtain the data. At this stage there is no emphasis on intellectual merit of the research program. Although the faculty were invited to push forward the required reading in their areas of interest (to advance their achievement as scholars), the emphasis at this stage is on acquiring the skill of writing for research purposes as indicated in this paper.

April 2017. At this stage there could still be some cases in which more writing practice is required, and this practice will continue as long as required. At this point, however, the emphasis should start shifting to evaluating the overall framework of each research program. Are there research questions that can easily be started with a minimum amount of funding (simulations, for example)? If there are no written research questions of this type, can they be generated? At this stage, the faculty will already possess the skill to write them. These initial research questions are important as they will provide a low-cost starting point for the research program.

May 2017. In this meeting the expectation is that 100% of the faculty members will have mastered the skill of writing for research purposes, as detailed in this paper. They will have also generated at least one research question which will serve as the initial point for conducting research. This research question will be low cost. If no research question comes to mind, the minimum will be to write a paper on "The state of the art in (fill in the blank with your research area)" which will guide the faculty member in the direction of scholarly achievement by inviting them to read papers in their field of interest.

Spring 2017 semester. The faculty will continue the monthly "Review Panel" meetings. The structure of the research programs created by each faculty member will become more solid in this stage. Additional research questions will be added, and others deleted, as each faculty member starts becoming a scholar in their field, and starts to improve the intellectual merit of their research programs. Statements of "Broader Impacts" begin to take shape.

2018. 100% of the faculty will have written at least one paper to answer one of the research questions. The level of scholarly achievement will have increased. One or two faculty members will have written excellent proposals for external funding with good reviews, but not necessarily funded.

2019. The faculty members are writing significantly more research papers, they are attracting more students to their research efforts, and are writing excellent research proposals some of which are funded. The faculty continue using their research program as their "work plan" to conduct research. New research questions are added. The amount of potential papers to write is staggering as is the material on which they could write good proposals. The faculty begin to manage their research efforts to avoid becoming overwhelmed by the potential number of publications and proposals that they could write.

2020. All the faculty of mechanical engineering have won at least one proposal for external funding for research. They will have also written at least one journal article. The faculty is well on its way to sustaining a solid research program.

VIII. Conclusions

This paper has presented a plan that may be useful to engineering institutions that have historically concentrated on teaching and are facing an uphill battle in their efforts to increase the research output of the faculty. Some of the many reasons that stand in the way of increasing research output are high academic loads, time spent away from research after PhD completion, and the lack of mentoring of the faculty.

This paper included the plan and the initial steps that have been taken to implement a bootstrapping operation that has the objective of increasing the research output of the faculty as measured by the number of published papers and the amount of external funding generated. It is based on the education triad on which learning is based, that is, guidance, practice and feedback.

Emphasis is placed on ensuring that each and every faculty member creates a structured research program. The structure serves as a "work plan" for their research effort. It includes writing appropriate research questions, writing research objectives in a form that is acceptable to NSF, becoming a scholar to clearly define the limits of knowledge in their field, writing potential titles for the papers that they expect to publish as a result of their research, writing "intellectual merit" and "broader impact" statements", and doing all of this in an ethical manner.

The build-up is expected to be gradual. The structure that will be created by each faculty member will serve as the basis for writing proposals that have a high probability of getting funded. The structure is also expected to assist the faculty in properly lining up assistance from both graduate and undergraduate students by identifying explicit outcomes that are appropriate in terms of level-of-difficulty for each group (graduate and undergraduate). All efforts will therefore be directed by the research questions that have been scholarly defined in the structure that guides the research.

The first few months will be spent guiding the faculty in developing high-level writing skills for research purposes. These include how to draft concise and focused research questions that point at the data that is required to answer them; how to write research objectives that are in a form acceptable to NSF; and envision potential paper titles. Once the writing skills are acquired, the focus is placed on scholarly achievement (reading in their respective fields) and on developing additional questions that could ignite their research efforts at a low cost (potentially with no external funding). Then the effort starts focusing more closely on writing successful proposals and managing their time. By 2020 all the faculty is expected to have won at least one research proposal and published one journal article in their field of interest.

IX. Acknowledgments

The author wishes to express his sincere gratitude to the faculty of mechanical engineering at Universidad del Turabo for accepting to participate in this effort. This same faculty was able to create a culture of outcomes assessment that ensured its ABET accreditation. It has also elevated its teaching capabilities through a five-year faculty development program that ended in 2016. Now is the appropriate time to elevate the research vector. The role of intrinsic motivation cannot be overemphasized. It is the sincere desire of the faculty to explore and investigate the unknown that will move this effort forward. This project in itself is nothing more than a way of organizing the work in a manner that will hopefully assist the faculty in their research endeavors.

There are still high academic loads, a shortage of graduate students to assist the faculty in research, a minimum of funding to get started, and other serious issues that need to be overcome. Hopefully, these very same issues that make this effort a very challenging one, will be resolved, or at least minimized, as the faculty gradually show their caliber in meeting the goals that have been set for this project.

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