



Recruitment & Retention Efforts in Engineering Education: A Proposed Strategy for Benchmarking

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Introduction

Many engineering colleges allocate both financial and human resources to attract and support prospective and current engineering students from historically underrepresented populations. In attempt to centralize these efforts, offices such as Minority Engineering Programs (MEPs) and Women in Engineering Programs (WEPs) are often charged with offering college-wide initiatives. This includes initiatives such as outreach programs for prospective engineering students^[1-3], summer bridge programs for transitioning engineering students^[4-6], and mentoring programs for current engineering students^[4,7,8]. While engineering colleges typically share the common goal of improving recruitment and retention, the specifics of these initiatives can significantly vary across universities. This variation makes it difficult for practitioners (i.e., those involved in leading recruitment and retention efforts) to learn from other institutions and, more specifically, successful practices are not always shared in a manner that facilitates benchmarking. Benchmarking is defined as “the process of identifying, understanding, and adapting outstanding practices from organizations anywhere in the world to help your organization improve its performance” (p. 294)^[9]. When benchmarking is not facilitated, it can lead to practitioners implementing intervention components inappropriately or disregarding shared lessons and practices entirely. As a result, the purpose of this paper is to highlight the key steps in the benchmarking process and to suggest an innovative methodology to streamline the information sharing practices used by practitioners in this context. In particular, we propose the Information Sharing Cycle of Student Intervention Benchmarking (see Figure 1) as a model for practitioners to follow. The model shows the connection between implementing interventions, sharing information, and learning from others. It is our hope that it will foster knowledge sharing between practitioners in a variety of contexts.

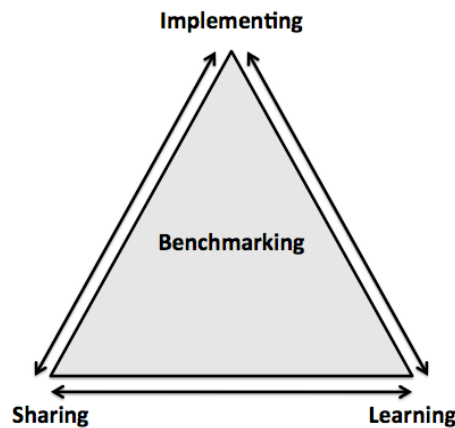


Figure 1: Information Sharing Cycle of Student Intervention Benchmarking

We begin this paper with a brief overview of benchmarking literature. Next, the conceptual framework (i.e., benchmarking model) used to simulate the benchmarking process and identify the key steps is discussed. We then review each phase of the conceptual framework in relation to

recruitment and retention efforts in engineering. Lastly, we offer advice for practitioners and propose a strategy for benchmarking recruitment and retention efforts in engineering education.

Benchmarking Literature

Benchmarking is commonly used as a *quality improvement strategy*. It was initially focused on business action and industrial processes, but its successful implementation has led to broader applications of the strategy ^[10]. While benchmarking is not as commonly used in education as it is in other sectors ^[11], previous research shows that the technique can be successfully implemented in educational settings ^[12-15]. One example of benchmarking applied in an educational setting can be found at Pennsylvania State University (Penn State). During the process of joining the Big Ten conference in 1990, the Penn State English department developed academic alliances with peer (i.e., Big Ten) institutions with similar goals and strong academic reputations such as Illinois, Indiana, Michigan State, Ohio State, Purdue, and Northwestern. Benchmarking the English departments at these universities allowed Penn State to strengthen its respective department by improving the tenure and promotion process and faculty development ^[15]. Although recruitment and retention practitioners often operate in environments that are functionally different than academic departments (i.e., engineering colleges), the method of leveraging partnerships within the benchmarking process can be useful in this context as well.

Conceptual Framework

While no universally accepted benchmarking process exists, benchmarking literature suggests that that four principles are fundamental across the numerous benchmarking models that have been developed: (1) *measurement*, or the collection of relevant performance data; (2) *comparison*, or the performance evaluation of the benchmarking subject against appropriate collaborators; (3) *identification of best practices*, or the detection of improvement areas and the development of an improvement plan; and (4) *implementation and improvement*, or the process of actually executing the changes ^[16-18]. Despite being represented consistently across models, the common principles are often accomplished differently through a variety of procedures. Since the procedures included in benchmarking models can vary, it is not always clear which models can be used for which types of benchmarking processes or in which contexts. In attempt to remove this ambiguity and determine which procedural components were essential to benchmarking, Anand and Kodali ^[18] conducted a study using a fundamental benchmarking model (i.e., Camp's "Xerox" methodology, which is highly cited and considered an effective and generic benchmarking approach) to benchmark 35 other benchmarking models from published books and journal articles. In other words, the authors participated in "benchmarking the benchmarking models" to identify common steps in the benchmarking process, or actions included in over 40% of the models in the sample. In addition to revealing common procedures in the benchmarking process, the researchers developed a 12 phase benchmarking model intended for universal usage. The phases included in their universal model are illustrated in Figure 2. In this paper, we used this model to define what steps were included in the benchmarking process to facilitate identifying the key steps. We discuss each phase in the context of recruitment and retention efforts in engineering in the results sections.

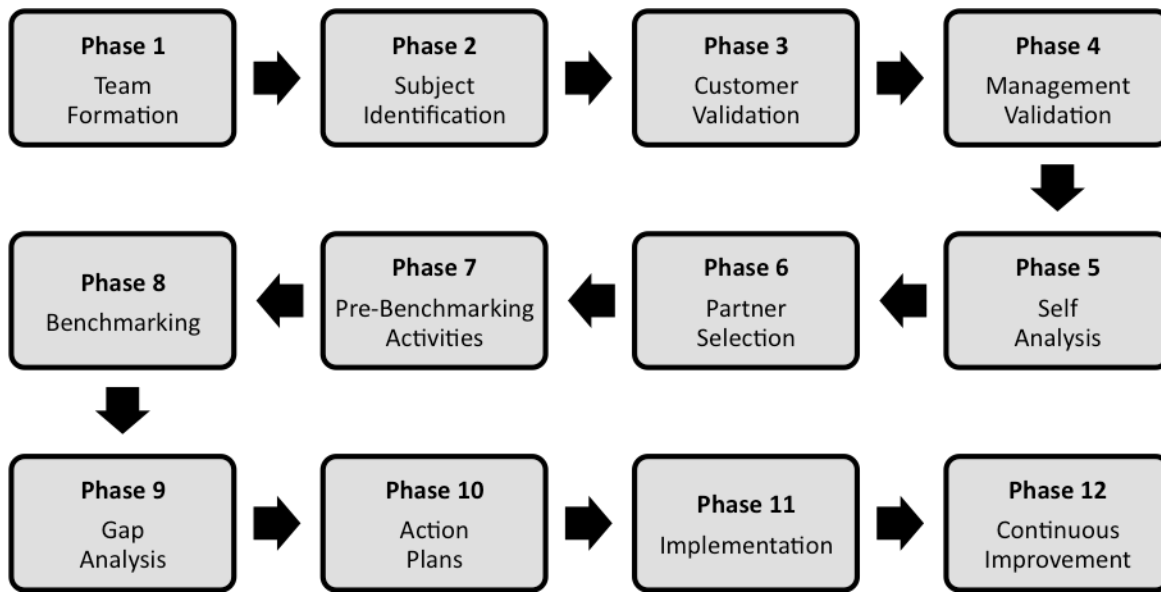


Figure 2: Conceptual Framework (Universal Benchmarking Model^[18])

Methods

To identify the key steps in a benchmarking approach, we simulated the benchmarking process with an individual office responsible for recruitment and retention efforts at a large, public, research-intensive university located in the southeastern region of United States. The research site (henceforth referred to as The Center) has served engineering students for more than 20 years and offers a variety of recruitment and retention initiatives. For current students, it provides residential communities for men and women, a five-week summer bridge program, and multiple mentoring programs. For pre-college students, it offers summer outreach programs, a recruiting weekend, and annual spring campus visits. It should also be noted that The Center administration includes a director, assistant director, numerous graduate students, and undergraduate student leaders. While actual benchmarking (i.e., phase 8) was not carried out, each of the previous phases were reviewed by the assistant director of The Center and the authors of this paper, each of whom has 3 to 12 years of experience with student interventions geared towards the recruitment and retention of underrepresented engineering students. The post-benchmarking activities (i.e., Phases 9 through 12) were also discussed to clarify what each phase entails.

Results

In the following section, we present a description for each of the phase in the universal benchmarking model previously discussed. Each section includes a description of the phase and how it was applied to the research site during the Benchmarking simulation.

Team Formation (Phase 1)

Forming a benchmarking team is the initial phase of the benchmarking process. During this phase, it is important that:

- A leader is identified to carry out the study;
- A benchmarking team is formed; and

- The capabilities of each member are identified so training can be provided if necessary.

With regard to The Center, the administrator responsible for directing the intervention of interest (e.g., summer bridge program coordinator) will be team leader. In addition to the leader, other individuals involved in the administration of the intervention will be included on the team; this could include staff, graduate student assistants, or undergraduate student leaders. With regard to the responsibilities and capabilities of each team member, it is important that each be clarified during this phase as the turnover for the graduate and undergraduate students who work for The Center is high, and the skills for the people in these positions can drastically vary from year to year. Additionally, including a benchmarking team member who specializes in assessment could assist with facilitating the training of other team members if necessary. As a result, the faculty responsible for assessment within the College of Engineering could be included on the benchmarking team as she is currently involved in the assessment of each intervention sponsored by The Center and has assessment experience that other team members may not possess.

Subject Identification (Phase 2)

Once phase 1 is complete and the benchmarking team has been formed, the identification of the benchmarking subject (i.e., focus of the benchmarking process) must be completed. During this phase, it is important that:

- The desired areas to be benchmarked are identified;
- The number of areas is narrowed down to key areas that can realistically be impacted;
- The importance of each area is determined based on priorities; and
- The final benchmarking subject(s) are identified.

Through multiple conversations between the assistant director of The Center and one of the authors, several desired areas to be benchmarked were identified. In particular, the assistant director was interested in benchmarking interventions with regard to the following components: (1) objectives and strategies; (2) designs and details, such as *how* and *when* things are taking place, who is doing what, and the associated costs; (3) specific activities, such as events after initial exams or mid-semester; and, at a higher level, (4) partnerships with campus collaborators.

According to the assistant director, the types of on-campus collaborations other practitioners have with internal university units is one of the more important areas for The Center because it has limited interaction with other units at its institution and could strengthen these relationships.

She also considered it useful to benchmark with regard to what other practitioners are doing for student leaders because this portion of The Center has grown organically (i.e., student leaders are involved in the administration of The Center sponsored interventions to a much greater extent than they were initially) and there may be things that can be improved by benchmarking the role of student leadership in engineering student support centers (ESSCs) that have existed for a longer duration. Since student leaders are in charge of many intervention operations, the assistant director believed that better assistance to them would trickle down and allow The Center to provide first-year students the best experience possible.

Customer Validation (Phase 3)

Once the benchmarking subject is identified, the customers of the benchmarking data should be considered. During phase three, it is important to:

- Identify the customers of the benchmarking information;

- Identify the expectations of these customers; and
- Validate the subject against the organization's missions, values, etc.

The Center's customers may slightly change depending on the intervention of interest. Generally, customers will include (1) the College of Engineering (COE), (2) residential life, and (3) The Center employees. Customers could also include corporate partners, funding agencies, advisory boards, or donors (i.e., alumni). According to the assistant director, the COE is typically interested in where pre-college kids are going and how well the current undergraduate students are performing academically. For example, regarding interventions such as the summer bridge program, COE wants to know if students are more successful than a control group of similar students who do not participate. With regard to benchmarking, COE may be interested in how summer bridge programs that are having more success are designed. Residential life may be interested in seeing if the interventions being sponsored are facilitating community development and whether or not students are being good residents. Residential life may also be interested in how the residential community impacts the RAs since the existence of the living-learning community changes their role: RAs assigned to the living-learning community do less programming and their goals can shift to developing one-on-one relationships with students and learning to collaborate with The Center. Ultimately, The Center wants to recruit and retain a more diverse group of students and help student get internship and job offers; as a result, administrators not directly involved in the benchmarking will be particularly interested in how other practitioners are retaining students and producing undergraduate students who are successfully competing for jobs.

Management Validation (Phase 4)

After the benchmarking subjects are compared to the expectation of the customers, it is important to:

- Develop the benchmarking mission and outline the purpose of the project;
- Identify resources required for the study; and
- Prepare a proposal for management.

The primary resource required from The Center to complete a benchmarking study would be employee work time: benchmarking may not be a current responsibility of the benchmarking team members. To justify the use of employee time—which may vary according to the type of intervention under analysis and the benchmarking subject—the assistant director believes the benchmarking team would need to demonstrate that the information collected during the process would strengthen interventions or assist The Center with securing future funding. Nevertheless, preparing a management proposal would not be necessary if the director assigned the benchmarking task.

Self Analysis (Phase 5)

Once phases 1-4 are complete, it is important to analyze the current state of the benchmarking subject(s). The self-analysis phase will include:

- Analyzing information the organization has on the benchmark subjects;
- Identifying critical success factors (CSFs) based on the benchmark subject(s);
- Selecting performance measurements for the CSFs;
- Measuring the existing state of the benchmarking subject(s) against the CSFs; and
- Documenting and characterizing the benchmarking subject(s).

With regard to The Center, several critical success factors were identified by the assistant director: (1) retention numbers; (2) GPAs; (3) recruitment results, i.e., where students going to college and what majors they choose; (4) employment results, i.e., where students are working, what they are doing, and how much money they are making; and (5) intervention operating expenses. Each of these factors is important to the success of The Center and is a critical indicator of the success interventions are having. Additionally, it is important to note that each CSF is not relevant for recruitment and retention interventions alike. For example, employment results will not be of interest when benchmarking recruitment interventions; instead, which college a student chooses to enroll in and what major they declare will be of primary interest.

Partner Selection (Phase 6)

Next it is important to select appropriate partners. The partner selection phase includes:

- Identifying sources of information that allow the collection of pre-benchmarking information;
- Identifying potential benchmarking partners based on this information;
- Establishing requirements for selecting benchmarking partners; and
- Comparing potential partners to narrow down the list.

In the case example, sources of information for pre-benchmarking information could include university websites, journal articles, and papers from professional conferences. The assistant director stated that administrators could find a lot of the information in practitioner papers from the Women in Engineering Programs and Advocates Network (WEPAN), the Society of Women Engineers (SWE), and similar organizations. The Center could leverage partnerships through these organizations or reach out to universities they are already aware of having similar interventions. For example, the assistant director was aware that Georgia Tech is one of the only places with a living learning community focused on STEM, and she identified them as a potential partner for a benchmarking study focused on the living learning community.

During partner selection, it is important to consider how the interventions are structured, how long interventions have existed, and how successful interventions have been. More specifically, the assistant director of The Center and one of the authors proposed the following requirements for selecting benchmarking partners and ranked them in order of importance:

1. Intervention Type/Model: It is important that the selected partners resemble the existing (or desired) intervention enough to bridge the gaps if there is a difference; there is only so much The Center can do with limited resources.
2. Focus/students targeted: It is important to know which students the intervention typically targets, i.e., all engineers, underrepresented engineers, all STEM majors, all undergraduates, etc., because this can change the context significantly.
3. Similar institutions: It is important to benchmark a similar institution because engineering colleges may have different resources and capabilities. The university type can also impact the type of funding practitioners seeks.
4. Success: It is important to know the impact the intervention has concerning the critical success factors (CSFs) identified in phase 5
5. Duration: It is useful to know how long an intervention has been in place.

As seen from the order of the selection criteria, there are several things to take into consideration when selecting a benchmarking partner for The Center outside of the CSFs. Even if an

intervention appears effective, several factors have to be accounted for before deciding whether an intervention or its components are transferable.

Pre-benchmarking Activities (Phase 7)

Once benchmarking partners are selected, there are several pre-benchmarking activities that need to be completed by The Center. First, a benchmarking protocol should be developed as well as a non-disclosure agreement that explains what and how information will be shared amongst the partners. If journal articles and conference papers are the primary sources of information, the non-disclosure and reciprocal agreements will not be necessary. However, in more active collaborations, expectations should be clearly defined and agreed upon initially to ensure that everyone involved benefits and the involvement of all parties is clearly understood. Next, a reciprocal agreement should be prepared to determine if partners are interested in benchmarking a different subject area. Lastly, it is important to determine what information is needed, which includes ensuring there is a clear understanding about what information will be collected and by whom. Each member of the benchmarking team should know their responsibilities, and inquiries that gather information about each of the agreed upon subject areas should be included.

Benchmarking (Phase 8)

The actual benchmarking phase includes collecting information through reports, surveys, interviews, and/or site visit, and can involve numerous methods. During this phase, it is important that information be sorted as it is collected and stored in a retrievable manner. As a reminder, benchmarking was not actually carried out during the conceptual simulation.

Gap analysis (Phase 9)

Once the benchmarking phase is completed, the benchmarking team will identify gaps and superior/innovative practices that can be used to strengthen the interventions offered by The Center; this includes evaluating the nature of practices to determine whether or not they can be adapted to fit the existing culture.

Action plans (Phase 10)

Once the gap analysis is conducted, the benchmarking team would prepare a report to communicate the findings with The Center stakeholders (i.e., those identified during the customer validation in Phase 3) and, if applicable, the benchmarking partners. For internal stakeholders, the report will include practical goals and an implementation plan to make the improvements identified during the gap analysis in Phase 9. Additionally, the report will assist the benchmarking team with gaining acceptance from management (if necessary) and any administrators not directly involved in the process. If the benchmarking process involved partners actively, the report provided to them should include what was agreed upon in the reciprocal agreements developed during Phase 7.

Implementation (Phase 11)

Once the action plan is developed, implementations should take place to close the performance gaps between the practitioner's site and the benchmarking partners. During this phase, the benchmarking team will:

- Prioritize the implementation of different action tasks;
- Develop a schedule with a target date for implementation and completion;

- Perform the action tasks; and
- Train employees, collaborators, and coworkers on the newly provided practices.

In order to improve the chances of the changes resulting in performance improvements, it is important that the implementation phase be carried out carefully. As a reminder, benchmarking was not carried out during the case application so was no implementation.

Continuous Improvement (Phase 12)

The last phase of the benchmarking process is continuous improvement. During this phase, the benchmarking team would monitor the resulting interventions to determine the ensuing impact. To ensure continuous improvement, the benchmarking process should be recalibrated and completed again. During the last phase, it is important to make sure the best practices are fully integrated and that a reward system is in place that encourages iterative and continuous improvement. Once results are obtained, the benchmarking report(s) should be updated to provide information on the best practices; this includes how it was implemented and how it was adapted into the existing organization. Once the process is completed to a satisfactory level, practitioners can perform new benchmarking studies with different subjects as necessary. As a reminder, implementation did not occur during the case application so there was no continuous improvement.

Discussion

Based on the simulation, we developed the Information Sharing Cycle of Student Intervention Benchmarking to highlight the key steps in the benchmarking approach. While attempting to demonstrate the application of benchmarking and show how recruitment and retention practitioners could use the process, we identified the interdependency between practitioners required for benchmarking to occur. Interdependence is a cooperative condition where all parties must contribute to successfully achieve the common goal (i.e., benchmarking)^[19].

Represented at each vertex in Figure 3, practitioners must contribute with regard to (1) **implementing** interventions, (2) **sharing** information, and (3) **learning** from others. If practitioners do not contribute in each of these ways, completing the benchmarking process, while possible, becomes more challenging and less efficient. In this section, we will discuss each side of the model and what it represents for practitioners.

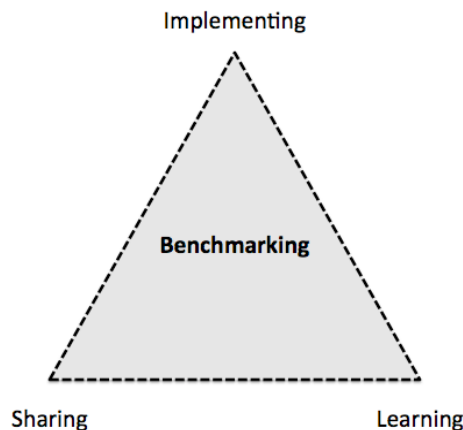


Figure 3 – Practitioner Contributions

First, practitioners must implement interventions and share them in a manner that facilitates benchmarking (Figure 4). Sharing is particularly important because practitioners often participate in passive benchmarking (i.e., using journal articles and conference papers) as opposed to active benchmarking (i.e., directly involving partner sites in a reciprocal benchmarking process). As a result, practitioners should report on interventions in a manner that allows each phase of the benchmarking process to occur even in their absence.

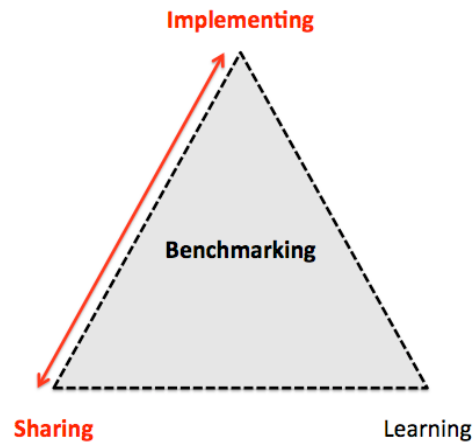


Figure 4: Implementing & Sharing

Based on the case application, the phases directly impacted by how sharing occurs are *Subject Identification (Phase 4)* and *Partner Selection (Phase 6)*. In regard to subject identification, sharing needs to occur in a manner that allows the reader to determine whether the information is **relevant** to their areas of interest. As a reminder, this can include providing the following information in a report: the objectives for the interventions and strategies employed; the design of the interventions and specific details; the activities included in the intervention; and the partnerships with campus collaborators to offer the intervention.

In regard to partner selection, sharing should occur in a manner that allows the reader to determine whether the results of the intervention are applicable. As a reminder, partner selection is important and involves variables related to the intervention itself and the sponsoring institution. Specifically, regarding the intervention, practitioners should consider including the following: the intervention type and duration (e.g., 10-week mentoring program); the selection criteria for the intervention; the targeted students and participant demographics; and the success of the interventions (i.e., performance data). In regard to the sponsoring institution, practitioners should consider including the following: college rankings; student demographics; campus type (i.e., commuter vs. residential campus); institutional structure (i.e., private vs. public); and admission process (i.e., selective admission vs. open enrollment). Ultimately, practitioners should implement interventions and share information in a manner that allows readers, who may be participating in a passive form of benchmarking, to determine if the information is relevant and applicable to their respective situations.

Next, practitioners should take advantage of the information that is shared, and learn from the experiences of other practitioners (see Figure 5). Learning is important because practitioners often have limited resources and there is a need to learn from the experiences of others in similar situations, particularly when they are employing more impactful and resourceful/efficient initiatives.

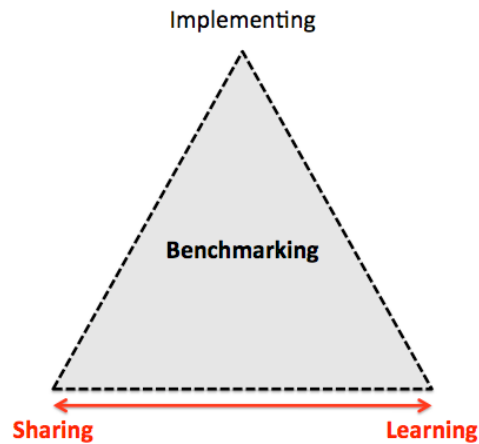


Figure 5: Sharing & Learning

Lastly, practitioners should implement action tasks based on the lessons they learn (see Figure 6). Implementing is important because it allows practitioners to upgrade their interventions and facilitates continuous improvement.

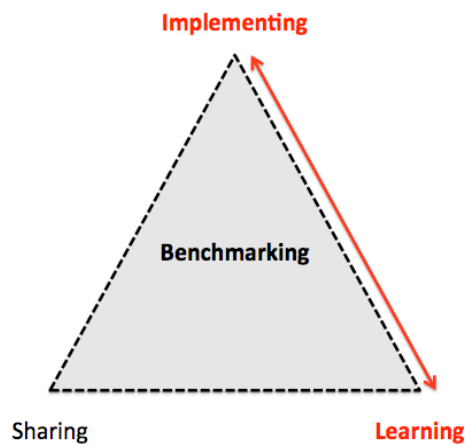


Figure 6: Learning & Implementing

As demonstrated in Figure 7, if practitioners participate in implementing interventions, sharing information, and learning from others, knowledge sharing between practitioners can be facilitated and benchmarking can occur more efficiently.

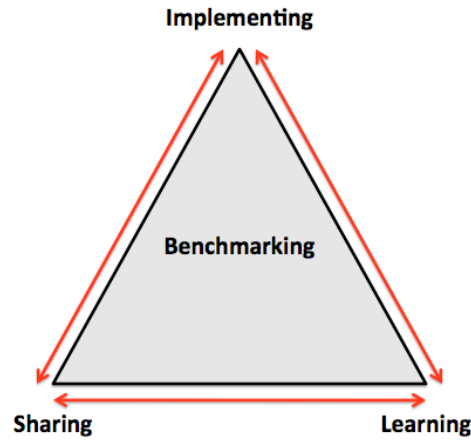


Figure 7 - Efficient Benchmarking

Additional Recommendations

In addition to encouraging practitioners to follow the Information Sharing Cycle of Student Intervention Benchmarking, we have four recommendations for recruitment and retention practitioners concerning the use of the benchmarking process included in this paper.

First, **practitioners should complete *Team Formation (Phase 1)* and *Subject Identification (Phase 2)* simultaneously** as subject identification can influence who is included on the benchmarking team (see Figure 8). While the phases were presented in a linear fashion, practitioners should consider this an iterative process and return to phases as necessary.

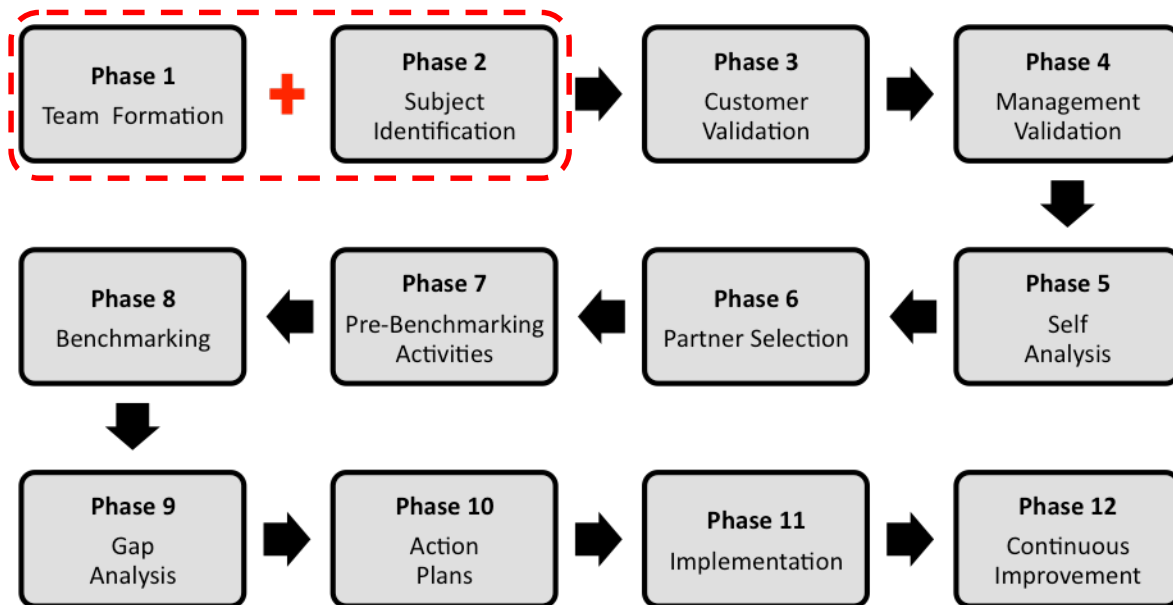


Figure 8 – Revised Conceptual Framework (Universal Benchmarking Model)

Second, **practitioners should include a person with assessment experience on the benchmarking team**, even if her or she is external; this person can provide an outside perspective and enhance the quality of the evaluation. Different practitioners will have access to people with different expertise and faculty/staff who could strengthen the benchmarking process should be included when possible.

Third, **practitioners should engage in passive benchmarking** (i.e., where info comes from journal articles and conference papers) when possible to save resources and take advantage of the information already available. Since reporting on recruitment and retention interventions is already common practice in the engineering education community (e.g., ^[5, 20-24]), this existing source of information should be used.

Last, **Practitioners should recognize the potential value of benchmarking partners that may be functionally dissimilar**. That is to say, the benchmarking process has been applied in educational settings where organizations are not functionally similar. For example, the School of Education at the University of Mississippi was able to benefit from benchmarking companies outside of the education sector such as Memphis Light, Gas, and Water, Fundcraft, IBM, and Federal Express ^[14]. In engineering particularly, the Virginia Tech College of Engineering was able to benchmark a group-mentoring program used by not-for-profit hospital to assist with new graduate nurses ^[21]. These examples support our argument that practitioners can use benchmarking to learn from a range of organizations that include dissimilar recruitment and retention interventions, student support services that do not target engineers specifically, and different types of organizational entities all together. In other words, practitioners who work with MEPs may be able to learn from WEPs as well as organizations that provide services outside of the academic domain.

Barriers of Benchmarking

In addition to our recommendations, we would also like to highlight barriers that can prevent organizations from implementing benchmarking initiatives as they relate to three categories provided by Amaral and Sousa ^[17]: (1) organizational barriers, (2) benchmarking project management barriers, and (3) benchmarking data barriers ^[17]. In this section, we define each category and mention specific barriers that we believe to be most relevant to recruitment and retention practitioners.

Organizational barriers are the result of people, culture, and context. More specifically, complacency is an organizational barrier. Practitioners may find themselves falling into a routine due to the limited time they have (between programs being offered and new students entering the university) to devote towards changing the way things are done.

Benchmarking project management barriers are the result of project planning/implementation, project leadership, and business pressures. More specifically, insufficient employee skills and resource constraints are benchmarking project management barriers. Since ESSCs are unlikely to be staffed with employees who have benchmarking experience, the impact the benchmarking process has may be limited.

Benchmarking data barriers, which are both a barrier category and a barrier, are a result of how difficult it can be to access and compare data and information. Since there is not a standard way of assessing the services provided by ESSCs and each institutional context may vary drastically, accessing and comparing performance data may be challenging.

While other barriers may present themselves, the authors' previous experiences working with recruitment and retention initiatives and the literature suggests that these specific barriers are likely to emerge. While these barriers may impede the use of benchmarking by recruitment and retention practitioners, we believe that the overall process is valuable and should be considered.

Conclusion

In conclusion, this paper highlight the key steps in a benchmarking process and offers suggestions for practitioners involved in this process with regard to the recruitment and retention efforts in engineering education. Because the work of practitioners can have similar missions, the lessons learned through this paper may be used to assist those who wish to carry out a benchmarking study or process.

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References

1. A. T. Jeffers, A. G. Safferman and S. I. Safferman, Understanding K-12 engineering outreach programs, *Journal of professional issues in engineering education and practice*, **130**(2), 2004, pp. 95-108.
2. J. F. Sullivan, S. E. Davis, J. L. Degrazia and D. W. Carlson, Beyond the pipeline: Building a K-12 engineering outreach program, *Frontiers in Education Conference*, 1999, pp. 11B15/21-11B15/26 vol. 11.
3. M. Yilmaz, J. Ren, S. Custer and J. Coleman, Hands-on summer camp to attract K-12 students to engineering fields, *IEEE transactions on education*, **53**(1), 2010, pp. 144-151.
4. G. S. May and D. E. Chubin, A retrospective on undergraduate engineering success for underrepresented minority students, *Journal of Engineering Education*, **92**(1), 2003, pp. 27-39.
5. S. L. Fletcher, D. C. Newell, L. D. Newton and M. R. Anderson-Rowland, The WISE summer bridge program: Assessing student attrition, retention, and program effectiveness, *American Society for Engineering Education and Annual Conference & Exposition*, June 24-27, 2001.
6. L. Lenaburg, O. Aguirre, F. Goodchild and J. U. Kuhn, Expanding pathways: A summer bridge program for community college STEM students, *Community College Journal of Research and Practice*, **36**(3), 2012, pp. 153-168.
7. C. A. Amenkhienan and L. R. Kogan, Engineering students' perceptions of academic activities and support services: Factors that influence their academic performance, *College student journal*, **38**(4), 2004, pp. 523-540.
8. J. L. Groh and B. M. Holloway, Complementary pair and group mentoring programs for undergraduate women in engineering, *Advancing Women: Transforming Engineering Education*, 2011.
9. A. Kumar, J. Antony and T. S. Dhakar, Integrating quality function deployment and benchmarking to achieve greater profitability, *Benchmarking: An International Journal*, **13**(3), 2006, pp. 290-310.

10. M. M. Yasin, The theory and practice of benchmarking: Then and now, *Benchmarking: An International Journal*, **9**(3), 2002, pp. 217-243.
11. R. Dattakumar and R. Jagadeesh, A review of literature on benchmarking, *Benchmarking: An International Journal*, **10**(3), 2003, pp. 176-209.
12. R. J. Novak, Benchmarking distance education, *New Directions for Higher Education*, **2002**(118), 2002, pp. 79-92.
13. M. R. Amin and N. A. Amin, Benchmarking learning outcomes of undergraduate business education, *Benchmarking: An International Journal*, **10**(6), 2003, pp. 538-558.
14. J. Payne and J. Blackbourn, Learning through benchmarking, *Journal for Quality and Participation*, 1993, pp. 62-62.
15. R. Secor, Penn State joins the Big Ten and learns to benchmark, *New Directions for Higher Education*, **2002**(118), 2002, pp. 65-78.
16. B. Deros, J. Tan, M. Rahman and N. Daud, An Effective Approach for Benchmarking Implementation, *American Journal of Engineering and Applied Sciences*, **4**(2), 2011, pp. 288-293.
17. P. Amaral and R. Sousa, Barriers to internal benchmarking initiatives: an empirical investigation, *Benchmarking: An International Journal*, **16**(4), 2009, pp. 523-542.
18. G. Anand and R. Kodali, Benchmarking the benchmarking models, *Benchmarking: An International Journal*, **15**(3), 2008, pp. 257-291.
19. J. F. Dovidio, S. L. Gaertner and K. Kawakami, Intergroup contact: The past, present, and the future, *Group Processes & Intergroup Relations*, **6**(1), 2003, pp. 5-21.
20. M. R. Anderson-Rowland, A. A. Rodriguez and A. E. Grierson, S-STEM programs for transfer and non-transfer upper division and graduate engineering and computer science students, *American Society for Engineering Education and Annual Conference & Exposition*, June 23-26, 2013, pp. 1-10.
21. W. C. Lee and K. J. Cross, Help me help you: Building a support network for minority engineering students, *American Society for Engineering Education and Annual Conference & Exposition*, June 23-26, 2013.
22. K. L. Jordan and S. A. Sorby, Pilot intervention to improve a "sense of belonging" of minorities in engineering (AC 2012-3317), *American Society for Engineering Education and Annual Conference & Exposition*, June 10-13, 2012 of Conference.
23. T. Waller, S. Artis and B. Watford, The Pact: A framework for retaining 1st year African-American engineering men, *American Society for Engineering Education and Annual Conference & Exposition*, June 24-27, 2007 of Conference.
24. M. R. Anderson-Rowland, A. Rodriguez, A. Grierson, R. Hall, P. McBride, J. Bailey, R. Pangasa, C. Vangilder and R. Cox, METSTEP: Third year review, *American Society for Engineering Education and Annual Conference & Exposition*, June 23-26, 2013, pp. 1-14.