Journal of Engineering Education Transformations,
Volume 30, No. 3, January 2017, ISSN 2349-2473, eISSN 2394-1707

Innovating Development of the NBA Graduate Attributes

Pradeep Waychal
Guruji Education Foundation, Thane (W)
Maharashtra, India - 400610
pradeep.waychal@gmail.com

Abstract: The main issue the Indian engineering education system has been facing ispoor employability. Earliersolutions to tackle the issue were unclear and now the NBA (National Board of Accreditation) has provideda solution by identifying a list of graduate attributes. The attribute list has defined what is to be done and has left the task of how it is to be done to the engineering institutes. The colleges are not able to manage the 'how' part due to theheavy curricular load and the paucity of qualified faculty. We present a solution of conducting a one-dayworkshop on 'innovating success' that can help develop the attributes and identify appropriate final year projects, which can further accentuate the development. We conducted the workshop at a leading college in the state of Maharashtra that was successful in providing opportunities to develop the attributes as per the participants' rating.

The workshop also provided a superior learning experience as per the overall workshop rating given by the participants. It was 4.5 out of 5. We need to extend the workshop to two days, or carry out iteration, or design a semester long course to strengthen the development.

Pradeep Waychal
Guruji Education Foundation, Thane (W)
Maharashtra, India - 400610
pradeep.waychal@gmail.com

Given the size of the Indian engineering education system, we would require effective scaling solutions.

Keywords : Graduate attributes, Innovation, Creativity, Employability, Active Learning

1. Introduction

Indian engineering education system has become the largest in the world with an annual intake of more than 1.6 millionstudents[1]The system has very little attrition unlike other national systems resulting in almost all the admitted students graduating. The system, however, is struggling with employability issues that are severely impedingenrollment, prospects of becoming a global supplier of engineering workforce, and growth of national economy. Various studies peg employability in the range of 20-30% [2][3]. The National Board of Accreditation (NBA) has defined a list of graduate attributes that are required to make the fresh engineering graduates employable and has developed a robust accreditation process[4].

A McKinsey and Company report says that more than 60% of all positions in the economy involve knowledge work by people who rely heavily on critical thinking, creativity, and interpersonal skills [5]. This makes developing theseskills a vital requirement to improve employability. We have been conducting a daylong workshop on 'innovating success'. The workshop has been receiving overwhelmingly positive feedback in India and other

countries such as Canada and Japan. Therefore, we checked if the workshop provides opportunities to develop the graduate attributes. Wewould require some follow-up actions to reinforce the development.

Our experiment at a leading college in Maharashtra provided early evidences of the workshop offering opportunities for developing the attributes to eleven of the twelve attributes. The paper presents the study and has sections on the workshop contents, research design that includes sampling, measurement, validity, and concluding remarks.

2. The workshop on Innovating Success

We have been conducting the workshop for the last few years with the basic objectives of teaching what innovation is, why it is required, and how one can actually innovate. The workshops have received overwhelming positive feedback barring a few exceptions [6]. We have developed a framework to build workshop contents for an individual instance of the workshop [6]. Based on the framework, we developed this workshop with the following modules.

A. Setting expectations and team formation

We seek participants' expectations, which generally tend to be learning something new. Then we impress upon the participantsthat learning requires engagement and full commitment. This paves the way for effective active learning. We then use any randomization technique to form diverse teams.

It has been found that diverse teams come up withmore innovative solutions[7][8]. Kurtzberg and Amabile [9] point out that diversity can enhance creativity owing to heterogeneous sets of perspectives. Hargadon [10] cites past innovations and demonstrates that many are the result of synthesizing or bridging ideas from different fields. Hansen and Birkinshaw [11] point out that the key metric to keep in mind is diversity of contacts, and not the mere number of contacts. Bessant et al. [12] suggest that individuals should not limit their search to fields they are already familiar with, but instead look at the edge of their radar screens and sometimes a bit beyond.

B. 3 H Model and Innovation

We explain that any activity requires 'head' to think, 'heart' to relate and 'hands' to execute. We demonstrate the role of each'H' (head, heart, and hand) with various exercises; some of them are drawn from Stephen Covey's popular book'The Seven Habits of Highly Effective People'[13]. The 3H model is also used by many other researchers [14][15][16].We cover meditation as an extension of the 3H model. The meditation technique usedis associated with "sustained and disciplined introspection", which is helpful for successful execution of an activity[17].Of course, weonly introduce all these techniques and appeal participants to practice them to reap benefits.

We point out that innovation is fresh thinking that delivers value to all the stakeholders [18], and drive home the point that any new idea requires pronounced relational and executional skills. We describe various global and Indian challenges to emphasize the need for innovation.

C. Innovation Process through design and development of water container

We narrate innovation process and carry out a 20-minute team exercise of developing a water container with the help of everyday objects such as newspapers, pencils, adhesives, staplers, etc. We tell the participants that their containers must be mechanically robust, aesthetically appealing, and should be able to hold 20 liters of water. The teams have to identify a team member as an observer, who cannot participate in the activity. Generally, participants come up with impressive containers. At the end of the exercise, the observers comment on the process and the faculty offer theirinsights.

D. Case Study

We distribute different case studies such as Titan, Shantha Biotech, Bosch[19], provide a template to study them and offer various suggestions for making good presentations. All teams have to make presentationsfrom daisand eachteam member has to speak.Patton and Applebaum [20] have cognized the use of case studies for general educational purposes. Gerald and Alfred [21] have argued that a trans-disciplinary case study can help develop creativity and social competencies.

E. Fresh Thinking (Creativity) Techniques

We discuss techniques such as '5 why', associating, questioning, observing, networking, and experimenting with appropriate exercises[22][23].

F. Value Delivery

We emphasize that the value delivery is more difficult than the fresh thinking part[24-26].We strengthen the argument with a number of real life examples and exercises.

G. Challenge

We stressthe importance of challenges in

innovation [19]. Upon listing various grand challengessuch as personalized education, economical solar energy, access to clean water[27], we ask each student to choose a challenge around their passion. The participants form teams, based on challenges,of up tofour members. They analyze their challenges using the framework that includes force field analysis technique. The analysis results in identification of projects to scale their challenges.

A workshop, at a leading autonomous college in Maharashtra, started at 930 AM and finished at 550 PM. It included only one break - a45-minute lunch break. We utilized thatto have informal discussions with various participants. We organized tea and snacks at the worktables as the participants did not opt for tea breaks. This was, perhaps, due to successful use of active learning strategies. We sought feedback on the workshop using a net promoter score method. We asked the participants, if they will proactively recommend, recommend, be neutral, not recommend and proactively not recommend the workshop to others. The responses were given the rating of 5,4,3,2,1, respectively. All the responses were in the proactively recommend or recommend categories and resulted in overall feedback of 4.5/5.

We have traced the development of graduate attributes to the workshop modules(table 1).We decided to exclude ethics and finance, as the workshop does not include those aspects. We excluded the word complex from the first five attributes due to impracticality of covering complex systems in a daylong workshop. We also simplified explanation without compromising the essence of the attributes. For example, we changed 'meet the specified needs with appropriate consideration for public health and safety,and cultural, societal, and environmental considerations'to only 'design system processes and solutions for engineering problems' in case of design attribute.

3. Research Design

We designed a study that included conducting a workshop, seeking feedback from participants on opportunities to develop graduate attributes, and triangulating the feedback with regular workshop end evaluations.

A. Objective, Scope and Type

The Indian engineering education system is fraught with poor employability. The education system that enhances creativity innovation skills and successfully develops graduate attributes can tackle theissue of poor employability. While the development has to happen across the curriculum, our study examines a possible solution of a daylong workshop.

Table 1: Tracing development of graduate attributes to the workshop modules

Graduate Attribute	Explanation	Workshop Modules
Engineering knowledge	Apply engineering knowledge for solving engineering problems	Water Container, Challenge
Problem analysis	Identify and analyze engineering problems , and reach conclusions	Water Container, Challenge, Case study
Design/development of solutions	Design system processes and solutions for engineering problems.	Water Container, Challenge
Conduct investigations of problems	Use research based methods including design of experiments, analysis and interpretation of data , and synthesis of the information	Water Container, Challenge, Case study
Modern tool usage	Create, select, and apply appropriate tools, techniques, and resources	Challenge, Creativity techniques
The engineer and society	Think of social problems and social consequences of your solutions	Why Innovation?, Value delivery
Environment and sustainability	Think of environmental problems andenvironmental consequences of solutions	Why Innovation?, Value delivery
Individual and teamwork	Function effectively as an individual, and as a leader in diverse / multidisciplinary teams	Team exercises, 3H
Communication	Effective oral and written communication with engineers and others	Presentation and group discussions, 3H
Project management	Apply the engineering and management principles to one's own work, as a member and leader in a team, to manage projects	Water Container, Challenge, 3H
Life-long learning	Learning something on your own	Case study

Our research is descriptive, diagnostic, cross-sectional, and mixed (qualitative and quantitative).

Wedescribe the characteristics of the population being studied and do not explore the reasons for those characteristics. We sought view of participants at a particular time making the study cross-sectional. Diagnostic research studies determine the frequency with which something occurs or its association with something else. Our research can be classified as action research as it was a disciplined process of inquiry conductedbya consultant with the help ofthe head of the organization i.e. by andforthose taking the action.

B. Sampling

We carried out the experiment in one of the leading autonomous engineering colleges in the state of Maharashtra. The college offers undergraduate, postgraduate and research programs in Chemical Engineering, Computer Science &Engineering, Electrical Engineering, Electronics & Telecommunication Engineering, Instrumentation Engineering, Information Technology, Mechanical Engineering, Production Engineering, and Textile Technology. The workshop covered forty students from the final year (senior) students of all the departments.

C. Measurement

We developed a form to seek feedback on the opportunities provided to develop the attributes. The form also had explanations of the attributes as showed in table 1. We explained the form and asked the participants to rate if the workshop provided them very good, some or no opportunities to develop the corresponding attributes. We quantified the three responses as 2, 1, and 0, respectively and calculated averages (Table 2).

Table 2: Opportunities for developing attributes

Graduate Attribute	Average Rating
Engineering knowledge	1.5
Problem analysis	1.8
Design/development of solutions	1.5
Conduct investigations of problems	1.6
Modern tool usage	1.5
The engineer and society	1.8
Environment and sustainability	1.7
Individual and teamwork	1.9
Communication	1.8
Project management	1.6
Life-long learning	1.7

We have not calculated statistical significance as the feedback indicates that there were development opportunities for all the listed attributes. The rating seems to be on the higher side due to unavailability of such opportunities in the regular curriculum and overall superior learning experience provided by the workshop. Engineering knowledge, Design/development of solutions and Modern tool usage seem to have the lowest rating, as the workshop did not provide enough opportunities for those attributes. The modern tool usage includes techniques, too. The participants perhaps missed out that aspect resulting in lower rating.

We sought workshop evaluation by asking the participants three things that they liked and three things that they disliked in the workshop. We manually tagged all the responses and then iteratively coded them until no further code changes (merging or demerging) were possible (Tables3a and 3b).Some researches call it as a grounded theory. However, the grounded theory, as defined by Strauss and Corbin [28], involves use of constant comparative method, meaning intertwining between the data collection in the field and analysis.

Since the workshop's main objective was to help students innovate, that appears to be the top most liked item. The workshop indeed had many thinking opportunities. Besides development of water container and coming up with a challenging project, we asked many questions throughout the workshop to the groups and individuals that required ample

Table 3a. What participants liked about the workshop

Likes	Count
Opportunity to innovate	16
Faculty	15
Identifying project	10
Active Learning	9
Teamwork	9
Confidence building	3
Meditation	3
Understanding innovation	3
Benefits of projects	2
Case study	2
Analysis of engineering problems	2
Communication	2
Others (Handling failure, motivation, stress handling, time management, understanding customers)	5

Table 3b. What participants disliked about the workshop

Dislikes	Count
None	10
No guidance on individual projects	5
Long workshop	5
No / less coverage of technology	3
Faster	2
Less break time	2
Only one day	2
Power issues	2
Should have done earlier	2
Others (Global discussion, More social aspect, Should have done earlier in the semester, identifying winners)	4

thinking / innovation. The participants seemed to have liked the faculty and were happy to identify a topic for their final year project.. The active learning and team assignments appear to have appealed to the participants. We had a meditation session just before lunch and three participants explicitly mentioned that they liked it.

There were few entries in the dislike area. Ten out of thirty-twoparticipants said that they did not find anything that they disliked. Some of the participants wanted to discuss their individual projects from various disciplines. We could not accommodate that due to time constraints and the faculty's paucity of knowledge of all the disciplines.

D. Validity

Creswell and Miller[29]have observed qualitative researchers employing member checking, triangulation, peer reviews, thick description, and external audits to demonstrate validity. They have defined triangulation, a widely used measure in qualitative studies in this context, as a validity procedure where one searches for convergence among multiple and different sources of information to form themes or categories in a study. Golafshani [30]and Rossman & Rallis[31] assert that data triangulation involved the use of multiple sources of data, data collection periods, and data collection methods. Besides asking the participants for opportunities to develop the graduate attributes, we also asked them to list likes and dislikes and triangulated them. Table 4 shows the result.

Table 4: Triangulation of opportunities for graduate attribute with the likes and dislikes of the workshop (Unless mentioned the feedback is about Likes, the number in the bracket is the count of the students who voted the likes or dislikes)

The above table indicates overall validity of the responses. Problem analysis and teamwork are aligned in both the datasets. We discussed the global challenges and their impact on society. That may have provided better rating for the attributes 'the engineer and society' and 'environment and sustainability'. We did not cover usage of modern tools but covered various techniques such as creativity techniques and force field analysis. That may have caused the rating to be one of the lowest for the attribute "Modern tool usage". The participants managed the water container exercise and also learnt various effectiveness techniques such as planning and time management. Of course,not all this is the same as managing projects, which may have resulted in the rating of 1.6 for project management. We could not also do enough justice to engineering knowledge and design/development of solutions resulting in the lowest rating for those attributes. Various opportunities for group discussions and presentations seem to have resulted in better rating for communication.

4. Concluding Remarks

The Indian engineering education system can fulfill the global engineering workforce requirements if it can address the employability issues. We can do that by ensuring development of the NBA graduate attributes. It should happen across the curriculum but for various reasons such as lack of time, unavailability of qualified faculty, that is nothappening. We therefore explored possibility of using a daylong workshop on 'innovating success' to provide opportunities to develop many of the graduate attributes. We can claim success in the attempt.

The workshop also provided many opportunities for critical and creative thinking. They are not explicitly mentioned in the NBA attributes list but are vital for many of the attributes.

We do believe that the workshop provided asuperior learning experience to the participants, which may have influenced the opportunities rating.

Going forward, we plan seeking elaborationfrom the participants to improve the rating. We posit that extending the workshop to two days may present better opportunities to develop graduate attributes as well as take care of the 'need longer workshop' feedback provided by some of the participants. Some participants did expect guidance on individual projects. The expectation was due to communication gap, which we intend to work on for the next iterations of the workshop. We also require finding solutions to develop the attributes such as ethics and finance that the workshop did not address. Given the size of the Indian engineering education system, we have to work on effectively scaling the workshops.

Acknowledgements

We would like to thank all the students who participated and the faculty members who supported the workshop.

References

1. AICTE. All Indian Council of Technical Education - Dashboard. 2016 [cited 2016 13-Sep-2016]; Available from: http://www.aicte-india.org/dashboard/pages/dashboardaicte.php.
2. Blom, A. and H. Saeki, Employability and skill set of newly graduated engineers in India. 2011.
3. Aspiring_Minds, National employability report of engineers 2016, Aspiring Minds.
4. Kottur shettar, B. and A. Shettar. Mapping Graduate Attributes of NBA with the Program Outcomes of the ABET/OBE to Establish Consistency between the Two. in Proceedings of the International Conference on Transformations in Engineering Education. 2015. Springer.
5. Rawson, G.e.a. How to scale personalized learning. 2016; Available from: http://www.mckinsey.com/industries/social-sector/our-insights/how-to-scale-personalized-learning?cid=other-eml-alt-mip-mck-oth-1608.
6. Waychal, P. A Framework for Developing Innovation Competencies. in 2016 ASEE Annual Conference & Exposition. 2016. New Orleans, US.
7. Ashcraft, C. and A. Breitzman, Who invents IT? An analysis of women's participation in information technology patenting. National Center for Women & IT, 2007.
8. London_Business_School, Men and Women in Teams. Lehman Brothers Centre for Women in Business, London Business School, 2007.
9. Kurtzberg, T.R. and T.M. Amabile, From Guilford to creative synergy: Opening the black box of team-level creativity. Creativity Research Journal, 2001. 13(3-4): p. 285-294.
10. Hargadon, A., How breakthroughs happen: The surprising truth about how companies innovate. 2003: Harvard Business Press.
11. Hansen, M.T. and J. Birkinshaw, The innovation value chain. Harvard business review, 2007. 85(6): p. 121.
12. Bessant, J., K. Möslein, and V. Von Stamm, In search of innovation. The Wall Street Journal, 2009. 22.
13. Covey, S., The seven habits of highly successful people. Fireside/Simon & Schuster, 1989.
14. Sipos, Y., B. Battisti, and K. Grimm, Achieving transformative sustainability learning: engaging head, hands and heart. International Journal of Sustainability in Higher Education, 2008. 9(1): p. 68-86.
15. Nichols, S.P. and N.E. Armstrong, Engineering entrepreneurship: Does entrepreneurship have a role in engineering education? Antennas and Propagation Magazine, IEEE, 2003. 45(1): p. 134-138.
16. Easton, F., Educating the whole child,"head, heart, and hands": Learning from the Waldorf experience. Theory into Practice, 1997. 36(2): p. 87-94.
17. Stauffer, M. and D.-E. Pehrsson, Mindfulness competencies for counselors and psychotherapists. Journal of Mental Health Counseling, 2012. 34(3): p. 227-239.
18. Appelbaum, R., et al., China's (Not So Hidden) Developmental State: Becoming a Leading Nanotechnology Innovator in the 21st Century. 2009.
19. Munshi, P., Making breakthrough innovation happen: how eleven Indians pulled off the impossible. 2009: Collins Business.
20. Patton, E. and S.H. Appelbaum, The case for case studies in management research. Management Research News, 2003. 26(5): p. 60-71.
21. Steiner, G. and A. Posch, Higher education for sustainability by means of transdisciplinary case studies: an innovative approach for solving complex, real-world problems. Journal of

Cleaner Production, 2006. 14(9): p. 877-890.

22. Taiichi, O. Ask 'why' five times about every matter. 2006 14-09-2016]; Available from: http://www.toyota-global.com/company/toyota_traditions/quality/mar_apr_2006.html.
23. Christensen, C.M. and M.E. Raynor, The Innovator's DNA. Harvard Business School Press, Massachusetts. Solution, 2003.
24. Waychal, P., et al., Towards a framework for innovations. International Journal of Business Excellence, 2011. 4(5): p. 493-518.
25. Sirkin, H.L., P. Keenan, and A. Jackson, The hard side of change management. Harvard business review, 2005. 83(10): p. 108.
26. Ashkenas, R., Change management needs to change. Harvard business review, blog, https://hbr. org, 2013. 4.
27. Perry, W., et al., Grand challenges for engineering. National Academy of Engineering, Washington, DC, 2008.
28. Strauss, A. and J. Corbin, Grounded theory methodology. Handbook of qualitative research, 1994: p. 273-285.
29. Creswell, J.W. and D.L. Miller, Determining validity in qualitative inquiry. Theory into practice, 2000. 39(3): p. 124-130.
30. Golafshani, N., Understanding reliability and validity in qualitative research. The qualitative report, 2003. 8(4): p. 597-606.
31. Rossman, G.B. and S.F. Rallis, Learning in the field: An introduction to qualitative research. 2011: Sage.