Deconstructing the Innovator's DNA

Mr. Paul David Mathis, Engineering Education

Paul Mathis is a PhD student in the school of Engineering Education and a council member for ASEE student chapter at Purdue University. He has a bachelors degree in Physical Science and a Masters in Education Curriculum. His areas of interest are design, innovation, creativity and improving skills of future engineers. pmathis@purdue.edu.

Mr. Nicholas D. Fila, Purdue University, West Lafayette

Nicholas D. Fila is a Ph.D. student in the School of Engineering Education at Purdue University, West Lafayette. His research interests include how engineering students approach, learn, and internalize design, especially in teams. He has co-authored a book chapter on teamwork and innovation, and has authored conference and journal papers on design, innovation, teamwork, and engineering laboratories.

Dr. Senay Purzer, Purdue University, West Lafayette

Decoding the *Innovator's DNA*

Abstract

Innovation plays a key role in transforming companies and markets. Engineers can contribute to this transformation by developing skills to innovate. *The Innovator's DNA* discusses the five major innovation skills used by experts[1]. A better understanding of innovative skills of experts and what sequence they were used may inform the education of future engineering students to help improve the development of their own innovative skills. This study used content analysis on innovation case studies from three different literature sources. From these three books 53 case studies were identified and coded based on the expert participants responses. Overall 67% of the experts used observation when coming up with their innovative product of process. Questioning was at 43% as the second most frequently used skill. Experimenting was used at the final stages of innovation 91% of the time. The majority of experts started with observation leading into questioning and finished with experimenting. This suggests that engineering students may improve their ability to innovate if they develop their skills in observation, questioning, and experimenting.

Introduction

Engineering helps drive innovation through the development of products, processes, and entrepreneurship opportunities[2]. These products are usually found desirable by consumers and their sales help provide jobs and commerce. Many companies, such as Apple, General Electric, and Samsung, use innovation to transform and create markets that provide financial benefits both nationally, and globally. Consensus in the field of engineering has focused on developing and preparing future engineers with the proper knowledge, skills, and tools necessary for them to succeed.

The five skills, embodied in *The Innovator's DNA* include association, experimenting, networking, observing, and questioning[1]. In the paper "*Defining and Measuring Innovative Thinking Among Engineering Under-graduates"* Amelink discussed recent literature that covers innovative thinking skills that can be learned, such as observation of processes and questioning[3]. While, the *Innovator's DNA* describes how these skills are used and contribute to innovative ideas, it does not explain which of these skills are more important or how these behaviors are linked.

The purpose of this study is to develop a better understanding of the five innovative skills through a content analysis of expert innovators. More specifically we answered the following questions: a) Which of the five skills do innovators most frequently use first in their innovation process?; b) With which of the five skills do innovators most often conclude the innovation process?; c) Which sequence of skills do innovators most frequently use?; d) Which skills are central to innovation?

Research Framework

Using the Innovator's DNA as a framework, this study identifies the sequences of skills used by successful innovators. The skills in question are observation, questioning, experimenting, association, and networking. These skills are defined in *The Innovator's DNA* as follows:

1. Associating is the ability to make connections with things from different areas of expertise, knowledge, or location.
2. Questioning is the ability to ask thought provoking questions on who, what, when, why, and push the questioning towards being a creative catalyst for the other skills.
3. Observing is seeing the world around them, the people living there, and noticing both what does and does not work in these situations.
4. Networking is the ability to link ideas and opportunities with others that work and play in the same or different areas of expertise then yours.
5. Experimenting is the act of trying out new ideas or processes in search of new data that may lead to an innovative opportunity.

The Innovator's DNA directs its focus at the five major innovation skills used by experts but does not explain which of these skills are more important and how these behaviors are linked to each other. We are looking to fill those gaps related to these five skills. The purpose of this paper is to develop a better understanding on innovative skills through a content analysis of experts and examine the possibilities of further study in applying it to teaching future engineering students.

> "One's ability to generate innovative ideas is not merely a function of the mind, but also a function of behaviors. This is good news for us all because it means that if we change our behaviors, we can improve our creative impact" [1].

Methods

We conducted a quantitative content analysis in order to identify the skills used most frequently during the innovation process[4]. Content analysis is empirically grounded approach used to analyze large amounts of text[5]. This research approach allowed us to explore an extensive amount of data from a variety of published sources. Thus we were able to efficiently compile a broad database of examples of the use of discovery skills during the innovation process that were sufficiently-detailed for this study. While, the analysis is limited to published text rather than interviews with experts, this approach allowed us to analyze of a larger number of innovators from all over the world, an approach that would have been too costly to do.

Data Sources

We established our criteria for identifying potential cases and reviewed related books. The selection chosen for analysis were based on four criteria. First, the book must have been listed among the 100 best-selling books in multiple innovation related fields (such as *technological innovations* and *creativity & genius*) from two major book retailers[6,7]. Second, the book must have received at least 50 citations according to Google Scholar[8]. Third, the book must be held by at least 500 libraries according to the *WorldCat* resource[9]. Finally, the books must have contained detailed descriptions of expert innovators and their innovation projects. Based on these criteria, three books were selected for inclusion: *The Innovator's DNA*[1], *The Medici Effect*[10], and *The Ten Faces of Innovation*[11]. Table 1 displays these books' performance on these criteria.

Innovation cases were identified from the written text. To be selected for analysis, cases must have been sufficiently detailed, describe an innovation, and the process the innovator used to develop that innovation. This step was necessary to ensure that we could code for the discovery skills employed during the innovation process. We identified and recorded 53 innovation cases for analysis. These individual cases are listed in the appendix.

Table 1. Ranking and References of Books

	The Innovator's DNA	***The Medici Effect***	***The Ten Faces of Innovation***
Times cited in *Google Scholar*	139 (including 81 references to abridged journal paper)	339	388
Library holdings (according to *WorldCat*)	654	861	995
Sales rank: organizational change (*Amazon.com*)	-	54	-
Sales rank: system and planning (*Amazon.com*)	33	-	65
Sales rank: creativity and Genius (*Amazon.com*)	-	81	-
Sales rank: Technology (*Amazon.com*)	56	-	-
Sales rank: decision-making & problem (*Amazon.com*)	51	-	-
Sales rank: Social & Cultural Aspects of Technology (*BN.com*)	25	24	25
Sales rank: Technological Innovations & Transference (*BN.com)*	6	4	-

Data Analysis

Two researchers coded each of the 53 examples based on a fixed coding protocol. These expert innovator examples are listed in the appendix. The coding protocol included specific examples related to the five innovator's DNA skills: observation, questioning, experimenting, networking, and association[1]. The researchers coded a discovery whenever the text used a word or phrase that described an action related to the skill (See Table 2). For example, the text on page 90 of *The Innovator's DNA*, "He noticed a lower-middle class man riding a scooter with an older child standing in front, behind the handle bars," was coded as observation.

Table 2. Coding Protocol

Skills	**Examples**	**Book Examples**
Association	Connecting, Creativity, Cross-pollinate, Combining	Marc Benioff came up with the idea for salesforce.com "It's basically enterprise software meets Amazon."[1]. (pg. 42)
Experimenting	Making, Prototyping, Creating, Developing	Jeff Bezos saw the Internet could be ideal for offering a catalog on books and felt he had enough data to run the experiment to see if books could be sold over the internet[1]. (pg. 135)
Observation	Watching, Seeing, Noticing, Observing	Ratan Tata noticed a lower-middle-class man riding a scooter with his wife and two other children on a very rainy day[1]. (pg. 90)
Questioning	Why, How, When, Where, What	Orit Gadiesh "do you really need all three hundred fifty products? Why do you have this? What is its core importance?" [1]. (pg. 61)
Networking	Bridging, Conference, Outside experience	During a trade show a speaker was describing a wireless data system when Michael Lazaridis came up with the idea for an interactive pager.[1] (pg. 114)

Inter-rater Reliability

Two researchers first discussed the coding protocol together and then independently coded each selected case. The percent agreement between two raters was 85% with a Cohen's kappa of $\kappa = .81$. This suggests strong inter-rater reliability. Both researchers reconciled coding differences through discussion and developed a unanimous coding for the 53 cases.

Development of Composite Process Diagram

We calculated the frequency of each skill; 1) used, 2) that initiated and ended the innovation process, and 3) that preceded each skill (Table 3). Based on the frequencies, we developed a composite process diagram, a modification of a state diagram. This graphic (Figure 1) demonstrates the percent of innovation cases in which each discovery skills begins and ends the process, as well as connects to each other state. For example, since questioning follows observing in 43% of the cases, an arrow from question to observing is marked with "43%". This graphic is useful for detecting overall patterns in use of discovery skills.

Results

Our analysis indicates that a majority of successful innovators have distinct patterns of behavior for discovery. Associating, experimenting, observing, and questioning were all employed in at least half the cases. Experimenting was used most frequently, most often at the end of the process. A majority of the case studies began with observing. Questioning and associating were frequently used in the middle of the process, linking observing to experiments. Thus, the most common path to innovation used was observation to questioning to experimenting. Alternatively, observing to associating to experimenting was used frequently.

Table 3. Total Frequency

	Frequency			
	Start	Middle	End	Totals
Associating	4	20	4	28
Experimenting	0	2	49	51
Networking	5	5	0	8
Observing	36	5	0	41
Questioning	9	26	1	36
Total	54	56	54	164

To help visualize the patterns of skills used, we developed composite process diagrams as shown in Figure 1. The thickness of each arrow is connected to frequency of the skills and the order experts chose. As shown here observation was clearly the winner on experts starting off their skills set. Experimenting was rated the highest finishing off 91% of the experts process. Networking was used occasionally in the beginning and in the middle of the process but never in the end.

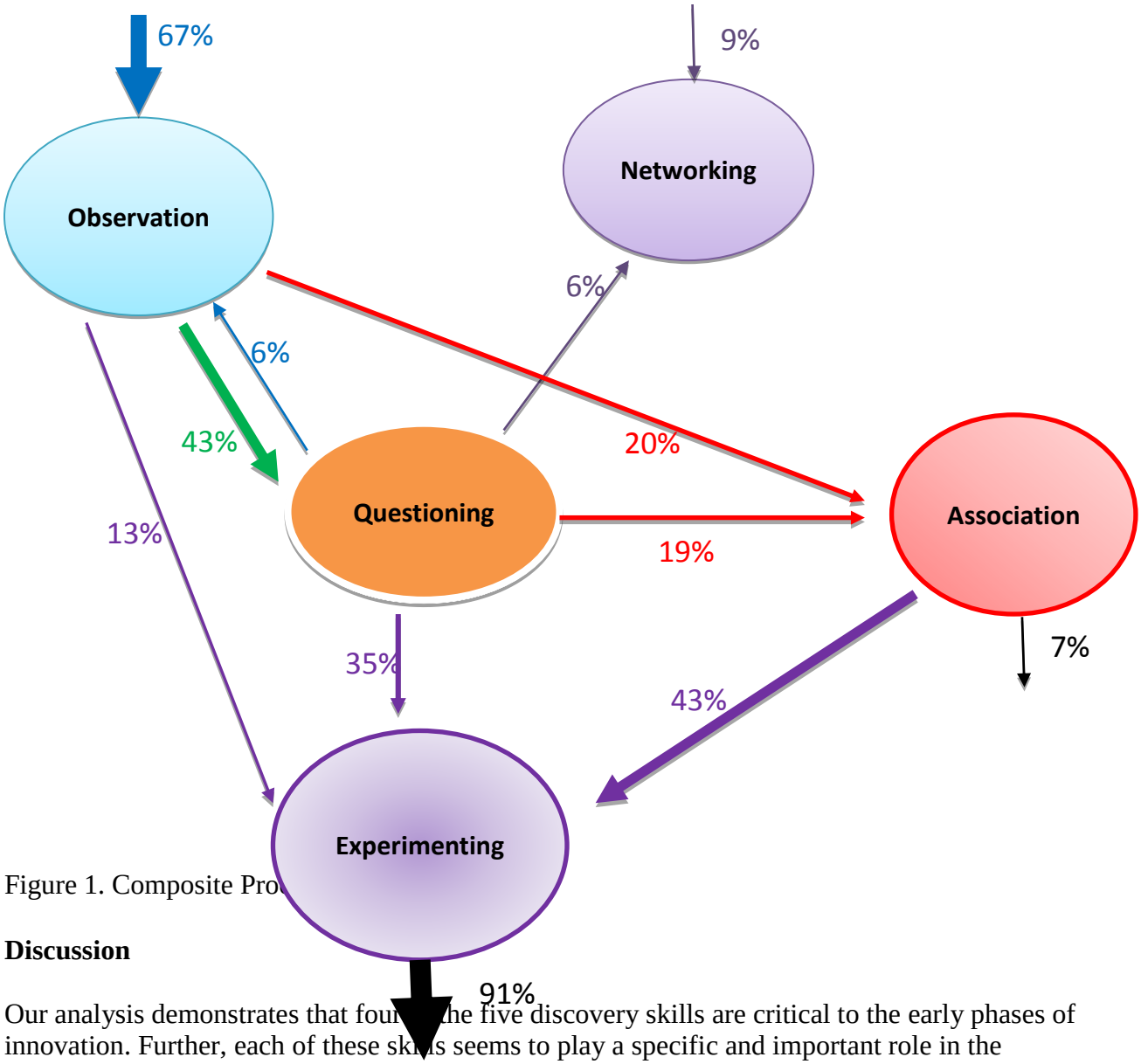

Figure 1. Composite Pro

Discussion

Our analysis demonstrates that four of the five discovery skills are critical to the early phases of innovation. Further, each of these skills seems to play a specific and important role in the innovation process.

Observing is more frequently used by innovators in the development of ideas that can lead to new innovations in technology and appears to be an important part of this process. The forming

of a question usually comes from observations that provided information from viewing a phenomenon. Observation almost always precedes questioning as the next stage of action.

Questioning was the second highest skill used by the innovators in the beginning of their process. and usually followed observation in each of the innovators processes. Observing a phenomenon can lead to the process of trying to explain that phenomenon which in turn leads to questioning or, in the case of innovators, questioning the status quo. Hofstein[12] describes questioning as

important to problem solving, creative thinking, critical thinking, and higher order thinking. This skill of questioning is what leads innovators to ask "why is it done this way?" and "what could we change to make it better?"

Experimenting was the most highly used skill between the five. Experimenting is the normal conclusion to most situations where an observation is made and questions are asked. After you have identified the question you would need to develop the test to run the experiment to answer the question. Entrepreneurship will not have any new products if there is never a result from experimenting. From experimenting companies or individuals would lead to the next stage of the production cycle of a product.

Association played an important role in some of the innovators' processes and was identified in *The Innovator's DNA* as a cognitive skill at the core of the innovator[1]. Association is not always apparent in the innovators process, but it is still important. Association is a skill that can lead to the creative creation of new products through combining different concepts or ideas. Innovators usually look for diverse situations and experiences. Innovators will try to be at the center of activity and information, such as a hub of cross cultural experiences. From here different ideas can develop from the observations made from the diverse groups and cultures mingling.

According to the case studies, networking was used by innovators less frequently than each of the other four skills. One interpretation is that networking is less important to the innovation process than the other skills. Alternatively, networking could be just as important but play a larger role in the latter stages of the product development process or be so ingrained in their creative process that innovators overlooked the skill in their discussions with researchers.

Conclusions

The results reveal two major patterns of behavior by the expert innovators. This is shown by the model listed in figure 1. Expert innovators use observation, questioning, and experimenting more often than association or networking. Observation and questioning are skills that students may not completely understand the value or importance when working in the innovation space. Engineering education should look into developing a deeper practice with these skills for future engineering students. If experts are using these techniques to develop global impacting innovations, then maybe these same techniques should be infused with current practices for students to reach a new level of understanding then they currently have when they graduate.

Based on these results we are suggesting that educators look into spending more time on activities that use these skills, such as observation and questioning, in class with engineering students. We feel that skill development in the areas could prove beneficial for young engineers in developing their skills of innovation. Faculty could have students practice Socratic questioning during team projects and presentations. Teachers could also take two minutes in the beginning of each class and have the students observe a picture and list all ideas, opportunities, and observations they make. Educators could have their students practice reflecting on their questions from the discussions in class and post follow up questions on a blog page.

Acknowledgments

This material is based upon work supported by the National Science Foundation Engineering Education Program under Grant No. 1150874. Any opinions, findings and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of Purdue University or the National Science Foundation.

References

1. Dyer, J., Gregersen, H. & Christensen, C.M. *The innovator's DNA: Mastering the five skills of disruptive innovators*, (Harvard Business Press, 2011).

2. Augustine, Norman R. "Rising above the gathering storm: Energizing and employing America for a brighter economic future (2008).

3. Amelink, C., Watford, A., Scales, G., Mohammandi-Aragh, J., & Farquhar-Caddell, D. Proceedings from ASEE 120th Annual Conference & Exposition: *Designing and measuring innovative thinking among engineering under-graduates*. Atlanta, GA (2013).

4. Boettger, R. K., & Palmer, L. A. Quantitative content analysis: Its use in technical communication. Professional Communication, IEEE Transactions on, **53**(4), 346-357 (2010).

5. Krippendorff, K. *Content analysis: An introduction to its methodology*. Sage (2012).

6. Amazon.com. Web, May 30 (2013).

7. Barnes & Noble.com. Web, May 30 (2013).

8. Google scholar. Web, May 30 (2013).

9. WorldCat. Web, May 30 (2013).

10. Johansson, F. *Medici Effect: What you can learn from elephants and epidemics*. Harvard Business Press (2006).

11. Kelley, T., & Littman, J. *The ten faces of innovation: IDEO's Strategies for Defeating the Devil's Advocate and Driving Creativity Throughout your Organization*. New York: Double Day (2005).

12. Hofstein, A., & Lunetta, V. N. The laboratory in science education: Foundations for the twenty-first century. *Science Education*, **88**(1), 28-54 (2004).

Appendix
List of expert innovator participants

1. Nate Alder	Klymit	Developed the idea of insulating climbing vests with Argon gas

2. Marc Benioff	Salesforce.com	First to offer online/on-demand downloads for software
3. Jeff Bezos	Amazon.com	Among the first online book retailers and developed online fulfillment capabilities
4. Edwin Land	Polaroid	Came up with the idea for developing pictures instantly
5. Scott Cook	Intuit	Among the first to offer personal finance and tax software Quicken and Turbo Tax
6. Gary Crocker	Research Medical Inc.	Introduced disposable medical products for surgeries for improved surgery
7. Michael Dell	Dell Computers	Developed direct-to-customer sales model in PC's, allowed mass customization
8. Orit Gadeish	Bain & Co.	Reorganized and redeveloped their business processes changing the way they had done business before

9. Niklas Zennstroom	Skype	Used supernode technology to place calls via the internet and deployed a unique viral marketing approach
10. Peter Thiel Max Levchin	Paypal	Among the first to offer financial services over the internet. Basically attached money to an e-mail
11. Ratan Tata	Nano car	Came up with the idea for the worlds cheapest car
12. Jennifer Hyman Jennifer Fleiss	Launched "Rent the Runway"	Netflix type business for renting designer dresses
13. Kristen Murdock	Cow-Pie Clock's	Took glazed cow manure and turned them into clocks with humor ideas attached to it
14. David Neeleman	JetBLue and Azul Airlines	Developed TV tech. at every seat, at-home reservations, hundred seat JetBlue
15. Richard Saul Wurman	Founder of TED	Combined the idea of technology, entertainment, and design making an idea accelerator.

16. Kent Bowen	Founding Scientist	Developed highly advanced and innovative ceramic composites
17. Chris Johnson	Cofounder of Terra Nova Biosystems	Developed a propriety process that ensures fast, cost-competitive remediation contaminants
18. Joe Morton	Founder of XANGO	Developed a health drink that turned into a billion dollar enterprise
19. Michael Lazaridis	Founder of Research in Motion (RIM)	Came up with the idea for blackberry smartphone.
20. Howard Schultz	Founder of Starbucks	Brought the romance and mystery of coffee to a little shop setting.
21. Corey Wride	Media Mouth	Company that helps you learn languages by watching movies
22. Chuck Templeton	Founder of Opentable.com	Developed an on-line app to allow customers to quickly find a restaurant like and get a reservation in one step
23. Dr. William Hunter	Start-up fonder of Angiotech Pharmaceuticals	Invented the first surgical stent that was coated with a drug to reduce scarring

24. Pierre Omidyar	Founded Ebay	Came up with a pen based computing application that attempted to make technology

		easier
25. Larry Page	Cofounder of Google	Combined connecting ideas, academic citations with web search
26. Steve Jobs	Apple	Came up with the idea for beautiful calligraphy for the Macintosh

27. Patrice Martin	IDEO up and coming star	Eating charts
28. Michelle Lee	Google patent lawyer	
29. Brendan Boyle	Zero20 gang	Musical balance beam
30. IDEO Group	IDEO	New nasal surgery device
31. Mary Doan	The Good Guys electronics retailer	Fold-out flat TV advertisement
32. Brownie Wise	Selling Tupperware	Came up with the idea of selling Tupperware at home parties
33. Earl Tupper	Creator of Tupperware	Figured out how to make Tupperware useful
34. Linus Trovolds	Linux	Developed a free operating system that is open source code that anyone can use as long as they share if they make any improvements

35. Danisco Inc.	Developes new food products	Came up with Frozen jelly on a stick (non-drip Lollypop)
36. Clarence Birdseye	Birdseye foods	Came up with using frozen food to keep it fresh and transporting it
37. Peter Coughlan of IDEO	IDEO transformation team	Staging cross-pollination outings with clients
38. Mohammed Bah Abba	Cooling pots in Nigeria	Developed pottery to keep food cool by using 2 pots placing one inside the other and using water evaporation to cool it.
39. Dick Fosbury	Olympic High jump gold medalist	Used lateral thinking to develop a new way to jump in high jumping that was more efficient than anything else ever done.
40. Kazuko Koike	Mujirushi stores	Came up with the idea of "No Brand" muji stores from American generic brands
41. Nils Bohlin	Volvo engineer	Created the first three-point seat belt
42. Kevin McCurdy	Founder of Zinio	Started a on-line magazine company before anyone else

43. Myra Goodman	Earth Bound Farm	Sealing organic fresh lettuce and selling it
44. Richard Branson	Virgin Airlines	Offer seat back entertainment
45. Richard Drew	Worked for 3M	Invented masking tape
46. David Kravitz	Organ Recovery System	Developed systems to help transport and preserve organ transplants

47. Sequoyah	Written Cherokee	Came up with the idea for a written language from observing soldiers reading orders

	language	and writing letters.
48. Marcus Samuelsson	unique food	Combines unique foods from all over the world using combinations never seen before
49. Richard Garfield	Magic the Gathering	Developed a card game that was ever changing, could be played relatively quickly, and incorporated cards that were collectable.
50. Robert Johnson	BET	Came up with the idea for BET
51. Hakan Lans	STDMA	Now considered the world standard for air and sea traffic navigation using GPS
52. Prothrow-Stith	Anti-violence curriculum	Developed anti-violence curriculum for students to help prevent violent acts
53. Eric Bonabeau	Swarm intelligence	Having programs that mimic the behavior of insects