

# The Keys to Innovation: Defining and Evaluating Attributes that Measure Innovation Capabilities

Mohammad Samarah, Benjamin Stark, Jennifer Kindle, Langley Payton

**Abstract**—Innovation is a key driver for companies, society, and economic growth. However, assessing and measuring innovation for individuals as well as organizations remains difficult. Our i5-Score presented in this study will help to overcome this difficulty and facilitate measuring the innovation potential. The score is based on a framework we call the 5Gs of innovation which defines specific innovation attributes. Those are 1) the drive for long-term goals 2) the audacity to generate new ideas, 3) the openness to share ideas with others, 4) the ability to grow, and 5) the ability to maintain high levels of optimism. To validate the i5-Score, we conducted a study at Florida Polytechnic University. The results show that the i5-Score is a good measure reflecting the innovative mindset of an individual or a group. Thus, the score can be utilized for evaluating, refining and enhancing innovation capabilities.

**Keywords**—Change management, innovation attributes, organizational development, STEM and venture creation.

## I. INTRODUCTION

INNOVATION is critical to the success of individuals, communities, organizations, nations and the world. Most industrialized nations make large investments in innovation to ensure a modern and growing economy. A critical aspect of this process is the development of academic research in innovation [1]. Although we have an overwhelming amount of information on the subject, we still do not fully understand how to be innovative and whether innovation can be learned or taught. The term "innovation" yields more than 600 million results searching Google, Google Scholar, CiteSeerX and Microsoft Academic Research, while the term "innovation research" yields about 0.5 million results. By comparison, the term "innovation traits", yields less than 2000 results and Microsoft academic search engine produces only 63 results [2]-[4].

Innovation is a big business as well. The major research consulting companies including Gartner Research, Forrester, and IDC produce hundreds of articles on this subject yearly. Gartner give their Eye on Innovation Award to innovators in certain business sectors [5] and publish innovation insight for specific business problems and domains from Deep Learning to Digital Experience Monitoring [6], [7]. Forrester has a dedicated division focused on innovation. They list nine analysts who cover innovation as their primary research area

Mohammad Samarah, Jennifer Kindle, and Langley Payton are with the College of Innovation and Technology at Florida Polytechnic University, Lakeland, FL 33805, USA (e-mail: msamarah@floridapoly.edu, jkindle@floridapoly.edu, lpayton3512@floridapoly.edu).

Benjamin Stark is with the College of Innovation and Technology at Florida Polytechnic University, Lakeland, FL 33805, USA (corresponding author, e-mail: bstark5128@floridapoly.edu).

[8].

There are also many non-profit organizations and non-governmental organizations (NGOs) dedicated to innovation. For example, Bessen founded Research on Innovation, a non-profit organization, conducting, sponsoring and promoting research on technological innovation both in academia and in industry [9]. The European Union provides an online portal to promote innovation. The site has more than 25,000 pages. Its stated mission is to help individuals learn about European research and innovation whether they are researchers or teachers, in business or in politics [10]. The European Commission on Responsible Research & Innovation is an initiative for a vision of Europe by 2020 that is based on open innovation, open science and open to the world [11]. The stated commission vision is an approach that anticipates and assesses potential implications and societal expectations fostering the design of inclusive and sustainable research and innovation [12].

In Open Innovation, the authors argue that the human element is the most fundamental aspect of innovation. They further state that although organization and process are critical, the human element is the only differentiator between successful and trailing innovation [13]. Dyer et al. identified five traits of innovators; however, their study focused on product innovation and it was based on data from CEOs of Fortune 500 companies. Their list includes: Associating, Observing, Questioning, Experimenting, and Networking. The authors studied 25 innovative entrepreneurs and conducted a survey of more than 3,000 managers and 500 individuals who either started an innovative venture or have invented some new product [14]. Other researchers looked at innovation traits as it applies to business innovation, team leaders, specific business domain, or a particular technical specialization [15]-[18].

Phillips identified 24 traits for selecting and finding high capacity innovators in an organization. Their list includes: Adjacency, Associative, Beginner's Mind, Collaborative, Comfort with Ambiguity, Creative, Curiosity, Empathy, Exploring/Experimenting, Flexible, Future Orientation, Holistic, Humility/Low Ego, Independent, Intrinsic Motivation, Lifelong Learner, Lower Fear of Failure, Optimistic, Patient, Proactive, Risk Taking, T-Shaped, Tenacious, and Unconventional. Phillips offers an online assessment tool for computing one's innovation capacity; they call InnoTraits™ assessment [19]. Kleinberg created a tool to measure what she calls Innovation Quotient Edge (IQE). Her study includes 9 traits: Collaborative, Experiential, Futuristic, Fluid, Imaginative, Inquisitive, Instinctual, Risk Taker, and

Tweaker. According to Kleinberg, there are 9 triggers of innovation and the combinations of the top two triggers are one's unique innovator profile [20]. Freiberg argues that innovation is everyone's job and describes an innovative person as someone who does something now and the one who makes something happen. She published a book titled "Do Something Now: Be the One Who Makes Something Happen" [21].

Dyer and Gregersen describe how to think different when it comes to product creation and business innovation. They base this work on their research in the innovator DNA [22]. McAllister and Wessley describe traits of highly innovative people and cultures. They base their work on studying habits as it relates to innovation in business and product creation [23], [24].

Merigo shows that a large portion of academic research on innovation is clustered within the major industrialized nations: USA, England, Germany, Italy and others. This trend is shifting as more developed and developing nations are conducting research in this area. In addition, looking at specific journals of innovation, the data show that this clustering does not hold true anymore and other nations make significant contributions to specific domains within innovation research [1].

Given the limited body of knowledge on research in innovation traits, we argue that innovation traits matter more than ever before particularly at the individual level as more and more organizations rely on highly skilled individuals to perform important tasks. The next section discusses our framework for finding innovation traits.

## II. THE 5G'S FRAMEWORK

This paper presents a framework for innovation in individuals and organizations. We studied professionals and students in higher education settings to identify attributes, habits, and traits that lead to high levels of innovation. We designed an instrument that measures five attributes we call the collective framework, the 5Gs of innovation that include being Gritty, Generative, Giving, Growing and Graceful. We identified those attributes based on a pilot study with a selected sample where we analyzed what characteristics successful faculty, staff members and students had. To do so, the participants had to answer a similar questionnaire as the one used in this paper as well as answer questions in an interview.

Our study shows that 61% of individuals with a high mix of these traits with a minimum score of 4 in all attributes identified themselves as innovators and early adopters of both technology and societal change. In measuring participants' innovation score, the i5-Score, we sought to validate what it means to be innovative. Five attributes were identified that measures a person capacity for innovation. In the next sections, we go through each one in detail.

### A. Grit: The Passion and Drive for Long-Term Goals

Grit is living life as if it is a marathon rather than a 2-mile dash. It is going after long-term goals day in day out, month in

month out, to see it through without tiring or complaining. Recently, one of the authors was visiting a scholar in Atlanta, Georgia. This individual had an interesting blended background. He is a trained physician and a practitioner in social sciences, theology and higher education. He said that the best students and professionals he worked with exhibited these characteristics: "They were first to arrive. Last to leave. They consistently overworked. And they never complained." In a way, the enlightened scholar summed up the Grit attribute as being driven, tenacious and positive. Duckworth has done much work on Grit. Her work is the leading research in this area [25]. Pink in Drive argues that the secret to high satisfaction and equally high performance is our need to direct our own lives, learn, create new things and to do better by ourselves and the greater world [26]. Our study shows that Grit is not only a predictor of personal success and satisfaction but also a major predictor of innovation and an innovator's capacity for success.

A friend of one of the authors, a trained psychologist, one summer day came by and volunteered to do exterior house pressure cleaning. When she was asked, "you are so kind but why would you want to do this on a sunny summer morning?" She said that "pressure cleaning is one of the few things in life where you can see immediate results." The realization that we need to work long and hard before we see results is a marked attribute of individuals and organizations with high levels of grit. In the words of Bill Gates, Sr. who said about his son Trey: "Trey worked at the same relentless pace for decades. Achieving anything of real significance in life requires hard work." [27].

Participants who identified themselves as gritty where more likely to pursue long-term goals consistently, had high aspirations, saw failure as a temporary condition, and had a core belief that if they worked consistently long and hard enough they would attain their goals. They saw success as a learned attribute that shrinks and expands with their efforts. Their vocabulary and daily language is filled with hopeful and positive terms as well as terms like "make", "design", "learn" and "opportunity". This further validates early works done by Kegan and Lahey in "How the Way We Talk Can Change the Way We Work", where language is used as a transformational tool not only of thought but also of action [28].

### B. Generate Anew: The Ability to Generate New Ideas, Products and Services

Being generative means creating ideas, generating ideas, creating products, and creating services beyond incremental and continuous improvement. It is having the audacity and the courage to think we can create new things; to think we can make an impact on others, our environment, the world and ourselves.

Participants who identified themselves as generative were more likely grittier than others who had low to medium idea generation output. Steve Jobs, the former CEO of Apple, once said, "I've always been attracted to the more revolutionary changes. I don't know why. Because they're harder." [29] We see that Grit and Generative work together to form a basis for

innovation. The aspiring innovator must have the drive to think anew and the audacity to generate anew. Those who had high levels of this attribute had a vocabulary filled with excitement and discovery, using terms such as "research", "design", "influence" and "work".

#### *C. Give to Others: The Ability to Give and Share Ideas with Others*

The ability to give and share with others is a fundamental attribute of innovators. This is true of individuals, groups, communities and organizations. We can draw examples of communities that have an open-door policy, frequent open houses and frequent guest speakers. We regard such communities as progressive and innovative. Looking at the industry, Open Source was seen as a movement that created most of the advances we see today in machine learning, big data and consumer devices among other areas. In fact, Sun Microsystems in their highest days capitalized on the Open Source model and sought to recreate their engineering culture around the idea that innovation happens here and elsewhere [30]. The same is true at the individual level. Giving allows us to have high levels of openness, collaboration and radical inclusion. By giving we have the courage to share ideas, products, services, labor and time with others within and outside our own circle to benefit humanity for both profit and meaning.

Participants, who exhibited giving, were more likely to have higher perceived personal growth than others. They see giving as a daily habit rather than a seasonal event. They give of themselves to others without expecting a return. They give happily from their most valued and treasured ideas and assets. The participants in this group were more likely to be more graceful than others. Their vocabulary is filled with caring and helping the common good as the most used terms in our study for a give-score higher than 4.0 were "helped", "poly", "project" and "students".

#### *D. Growth Mindset: The Ability to Learn Adaptive and Technical Skills at All Ages*

To have a growth mindset, one learns at all ages, stages and phases throughout a person's life or an organization development cycle. In doing so our self grows, our mind grows. We foster new habits. We shed old habits. We become someone else. We become a better version of ourselves. Dweck's work on growth mind-set is a leading research in this area. She studied the benefits of teaching children that the capacity for intelligence is not fixed [31]. We argue that these benefits are equally applicable to adults and people of all ages. Kegan and Lahey, in *Immunity to Change*, show how our individual beliefs and group mind-sets combine to create a natural and powerful force they call immunity to change. The authors cite that "A recent study showed that when doctors tell heart patients they will die if they don't change their habits, only one in seven will be able to follow through successfully." [32]. They further show that by understanding what holds us back, we can move forward embracing change and becoming a change driver. Kegan and Lahey show that the development

from a socialized, self-authoring mind to a self-transforming mind is comparable to the progression of a team player and an independent leader to an interdependent Meta leader.

Participants who exhibited high levels of this attribute were more successful innovators. They were more likely to adapt their innovation as time and events shape their knowledge and assumptions. They realize that techniques and methods must adapt to time, location and people while universal principals hold true and unchanged. This group believed that their capacity for learning both technical and adaptive skills is not fixed and that with their efforts they can grow to any level. In addition, they believed that their growth allows them to see multiple contradictory perspectives at the same time while driving their innovation goals forward. This further validates the concept of a self-transforming mind as described in [32]. Their vocabulary is filled with terms that show the thirst for learning, excitement for discovery, and deep understanding of others. They used the terms "learn", "projects", "knowledge" and "university" very commonly.

#### *E. Grace: Humility, Kindness and Optimism*

Grace is as fundamental to innovation as Grit. Without grace, innovation becomes a rat race rather than a pursuit of high goals to advance human kind. Grace is humility, kindness and optimism delivered and carried every day. Grace is being happy throughout the innovation cycle. It is being happy but not content to pursue another angle and to try again. It is acting with grace, whether the innovation is at the top of the mountain or struggling in the valley. Grace is realizing that whatever situation we are in is a temporary condition and therefore kindness and optimism will drive our innovation much further than harshness and cynicism.

Although generating new ideas, creating products and services may yield fame and stardom, we are doing so while being graceful, patient, kind, humble with full knowledge that our ideas and contributions as lofty as they are, they are only a small part of the overall human progress. We do this while knowing that these ideas collectively together from others and us can make all the difference in the world. Therefore, at the heart of being innovative means to embrace and extend, to have an open mind, to realize our limits and that there are no limits to our collective potential.

In a recent speech on May 7th at the 2017 John F. Kennedy Profile in Courage Award, former President Barak Obama said that President Kennedy was "unwilling to consider the possibility that we might not win the space race because he had an unwavering faith in the character of the people that he led: resilient, optimistic, innovative and courageous." He went on further to say that, "Any fool can be fearless. Courage, true courage, derives from that sense of who we are, what are our best selves, what are our most important commitments, and the belief that we can dig deep and do hard things for the enduring benefit of others." [33].

Participants who identified themselves as being graceful were more likely to succeed in carrying their innovative ideas from concept to realization. They tended to be happier and more satisfied. Their language is filled with terms of hope and

optimism such as "great", "feel" and "proud".

### III. METHODOLOGY

To further analyze the characteristics of innovators and test our framework, we analyzed data of a survey answered by students, faculty and staff members at Florida Polytechnic University. Questions were identified that lead to a conclusion for the 5Gs for each of the responders based on a pilot study of a small random sample and review of current research in this area. Furthermore, the analysis of the questions aims to help guide innovation at Florida Polytechnic University; the only core STEM focused university in the state of Florida.

The survey for faculty and staff members included 27 questions, of which four questions were mapped to grit, four questions to generative, four questions to giving, one question to growth and three questions to grace. Similarly, for students, there were overall 27 questions. Four questions can be mapped to grit, four to generative, three to giving, one to growth and three to grace. This distribution of questions was the result of the pilot study and the research mentioned above. Furthermore, one of the questions asked the participant to categorize herself in an Innovation class. This is one of 5 classes: Innovator, Early Adopter, Early Majority, Late Majority or Laggard. The innovation class is based on the diffusion of innovations theory, made popular first by professor Rogers, in his book Diffusion of Innovations [34] and recently by Moore in Crossing the Chasm [35]. The analysis will always refer to the different groups in this innovation class, illustrated in the technology adoption curve in Fig. 1.

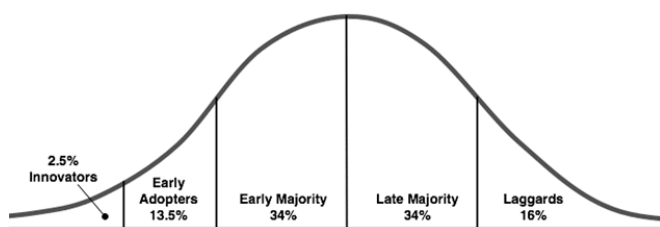


Fig. 1 Technology Adoption Curve [33]

The remaining questions in the survey instrument were on demographics and general information. Some of the questions also contained free-form text fields.

The results were pre-processed and aggregated so they can be utilized for various analyses. Therefore, all questionnaires not completed were excluded. Then, at first, we applied a text mining algorithm in Weka to evaluate the free-form text fields. Therefore, a StringToWordVector, using a Snowball stemmer and Rainbow stopwords handler, shows which terms were used the most by the different innovation classes, separated by faculty/staff and students. The results of this analysis were already mentioned in the previous section. Additionally, the demographics were analyzed for each of the innovation classes. Moreover, we created an individual score per trait based on the corresponding questions. To do so, each question received an individual score, depending on the

number of questions and the possible number of answers to those questions, with higher scores being better. This score is based on the Likert scale.

For each characteristic, the score per question is added up to a total score. This allows the calculation of an average per innovation class.

In the end, the individual scores per trait can be weighted and consolidated in one new, overall innovation score which we call the i5-Score. This score shows the innovative potential of a person. As the height of the score differs per trait due to the different number of questions and possible answers and to more easily compare the scores per trait, we normalized the score per trait as well as the i5-Score on a scale from 1 to 5 using (1). An innovation scale based on a 5 points scale is validated based on the following assumptions: 1) A baseline innovation score is expected of individuals and organizations, 2) The variability in each attribute is small and therefore using a large measurement may create an inflated score, and 3) Although the technology adoption curve has five regions, most individuals and organizations do not fall in a single region. Our data show that individuals tend to overlap two regions, and in rare cases may span three with a strong incline to a single one. Therefore, an innovation score based on a 5 points scale is most meaningful and should represent one's innovation potential more accurately.

Equation (1) shows the computation of the normalization of the i5 score. The range of [a, b] is [1,5], x is the average score, min(x) and max(x) being the minimum and maximum possible values for x for the corresponding trait.

$$x' = (b - a) \frac{x - \min(x)}{\max(x) - \min(x)} + a \quad (1)$$

The weight of the five traits is two for Grit and Grace and one for the other three characteristics. The reason for that is, in the opinion of the authors, Grit and Grace are the fundamental characteristics required to be innovative. Not being able to deal with failure and going on after failure resolves in giving up on innovation. Also, not having the desire to be innovative to create something for others is likely to result in not being successful.

### IV. RESULTS

First, the demographics evaluated will be presented. This includes a comparison between faculty, staff and students with regards to different age ranges, gender, years of service and student classifications. Second, the result for the i5-Score is shown.

#### A. Demographics

Overall, 101 faculty and staff members completed the survey as well as 140 students. Approximately the same amount of faculty and staff identified themselves as Innovators (11.9% staff and 10.9% faculty), whereas a higher percentage of staff members classified themselves as Early Adopters (29.7% compared to 18.75%). The same is true about employees being part of the Late Majority (2.3% staff,

8.1% faculty). Most of the faculty, 40.5%, and most of staff members, 48.4%, categorized themselves as Early Majority. Overall, more staff (63.4%) than faculty members (36.6%) participated in the study. It is interesting to note that none of

the faculty and staff members categorized themselves as Laggards. Similarly, for students, 40.6% identified themselves as Early Adopters, 37.1% as Early Majority, 12.6% as Innovators, 4.2% as Late Majority and 5.6% as Laggards.

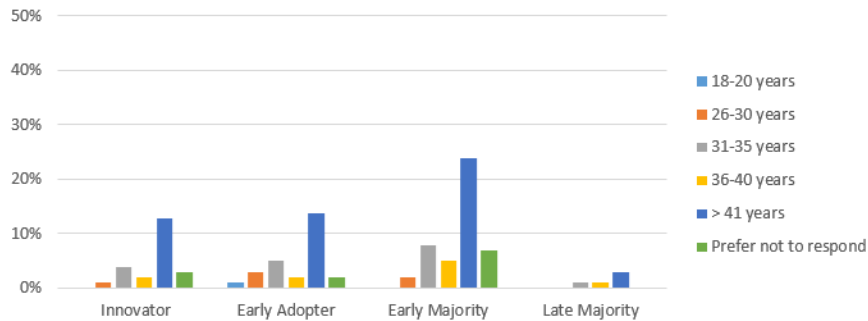


Fig. 2 Comparison of Faculty/Staff Age Ranges between the Innovation Classes

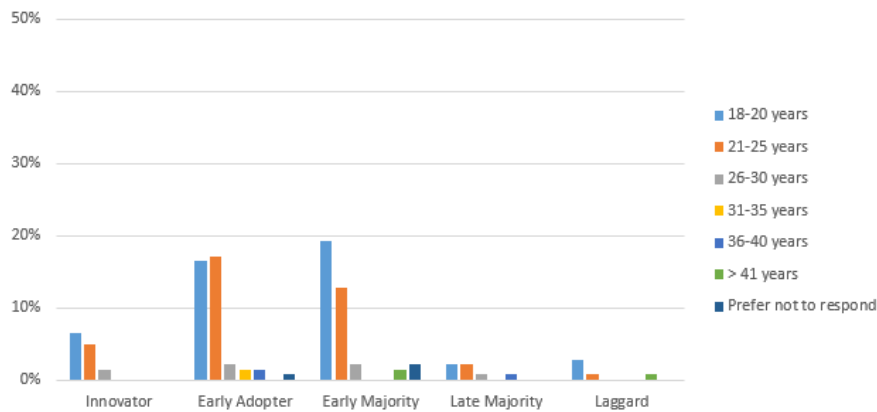


Fig. 3 Comparison of Students Age Ranges between the Innovation Classes

For faculty and staff, most of the participants were older than 41 years old (53.5%). This is also the largest group in all innovation classes. For students, the largest groups were age range 18-20 years old (46.2%) and 21-25 years old (37.1%). The distribution of the age categories between the innovation classes seems consistent: the groups in 18-20 years old and 21-25 years old are the largest groups per innovation class (each approximately 1/3 of the counts). Also, Innovators were mostly from this group (88.9%).

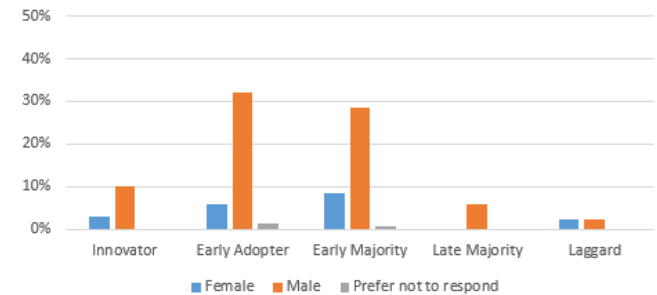


Fig. 5 Comparison of Student Gender between the Innovation Classes

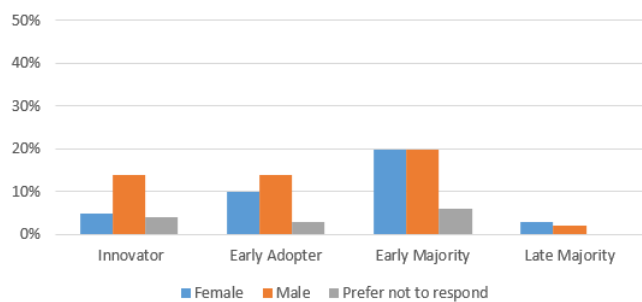


Fig. 4 Comparison of Faculty/Staff Gender between the Innovation Classes

Within the faculty and staff members, mostly men identified themselves as Innovators (73.7%). For Early Adopters, the ratio is approximately 66.6% male and 33.4% female, whereas for Early Majority it is 50% male and 50% female. For students, men identified themselves mostly as Early Adopters and Early Majority. For Innovators, 77.8% were male. Most participants were male (56.8% for staff/faculty and 80.0% for students).

Faculty and staff members working 3 or more years identified themselves mostly as Early Majority (48.6%), followed by Early Adopters (29.7%) and Innovators (17.6%).

With 2-3 years of service, employees were mostly Innovators (38.9%) and Early Majority (38.9%). Mostly, employees with 3 or more years of service participated in the survey.

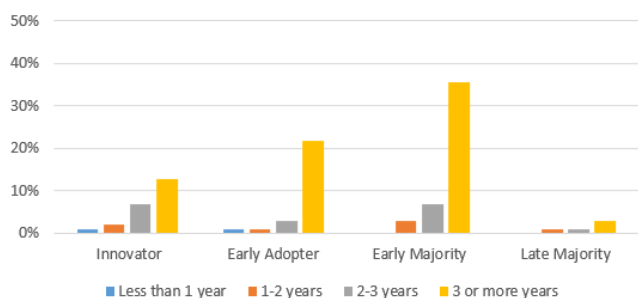


Fig. 6 Comparison of Faculty/Staff Years of Service between the Innovation Classes

Most students identifying themselves as Innovators were juniors (14.6%), followed by sophomores (11.9%) and seniors (10%). Most sophomores (52.4%) and seniors (47.5%) see themselves as Early Adopters, whereas most juniors (43.8%) see themselves as Early Majority. Laggards are almost equally distributed between freshmen, juniors, sophomores and seniors.

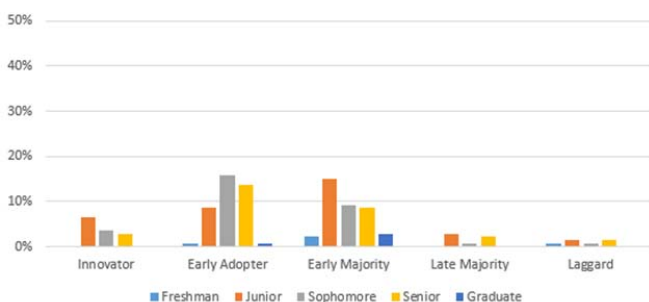


Fig. 7 Comparison of Students Categories between the Innovation Classes

### B. The i5-Score

The normalized scores for the i5 Score are shown in Table I. Innovators have the highest score for faculty/staff for the traits Generative, Grow and Grace. Student innovators have the highest score in traits Grit, Generative, Giving and Growing. For the Grit score for faculty/staff, Early Adopters have the highest score with a difference of 0.02 points. For Giving trait, Laggards have the highest score, followed by Early Adopters and Innovators. For students, Early Majority has the highest score for the Grace trait, followed by Early Adopters, Innovators, Laggards and Late Majority.

It is interesting to note that the score for the Giving trait is low compared to the other traits which are all above a score of 4. The i5-Score, however, decreases for faculty/staff from Innovators to Late Majority. For students, it decreases from Innovators and Early Majority and from Early Majority to Late Majority. For Early Adopters and Early Majority classes, the score has a difference of 0.02 points and a 0.2 points difference from Late Majority to Laggards.

TABLE I  
THE 5GS AND I5 SCORES

Trait	Group	Innovators	Early Adopters	Early Majority	Late Majority	Laggard
Grit	Faculty/Staff	4.22	4.19	3.74	3.23	N/A
	Students	4.26	3.91	4.00	3.46	3.81
Generate	Faculty/Staff	4.79	4.44	4.14	3.60	N/A
	Students	4.72	4.23	4.09	3.60	3.60
Give	Faculty/Staff	3.39	3.51	3.30	3.53	N/A
	Students	3.00	2.23	1.93	2.09	2.11
Grow	Faculty/Staff	4.13	4.02	4.01	4.04	N/A
	Students	4.46	4.20	4.17	4.10	4.34
Grace	Faculty/Staff	4.24	4.11	4.05	3.55	N/A
	Students	4.05	4.09	4.20	3.77	3.91
The i5-Score	Faculty/Staff	4.17	4.07	3.79	3.41	N/A
	Students	4.24	3.93	3.95	3.51	3.71

### V. DISCUSSION

The demographics analysis shows that innovation potential of faculty and staff does not depend on their age range. Innovation happens in all age groups. Although most of the innovators were more than 41 years old, this group is the largest in all other innovation classes leading to a sample bias. Additional samples with a different age group mix are needed to analyze this further. Similarly, for students, the sample is biased in favor of the largest students group, participants with age between 18 and 25. It is interesting to note that the student innovation classes are similar to the reference technology adoption curve. Therefore, we argue that based on proportions per age group, innovation happens in all age groups amongst faculty, staff and students.

For male and female faculty and staff participants, it can be seen that innovation happens in both genders equally, although there are more male than female innovators. In other innovation classes, the genders are similarly distributed. This may be attributed to sample bias and that men may overestimate their innovation capabilities while women may underestimate it. In general, the data sample has a good mix of men and women. For students, the male participants are the largest group in all innovation classes except laggards. This is expected as the study was conducted at a STEM university with a high percentage of male students. Thus, we argue that innovation does not depend on gender. Considering the ratios, we see that men and women are similarly innovative and represented in all categories.

With regards to years of service for faculty and staff, the results show that innovation happens during all years of service. Although most of the innovators served for 3 or more years, this is due to differing group sizes. For student categories, most innovators are juniors, but almost each category had participants identifying themselves as innovators. In the largest two innovation classes, early adopters and early majority, all student categories were represented. The differences between the groups might be due to sample bias. Therefore, we argue that innovation happens in all student categories.

To summarize, we argue that innovation is not limited to any specific group and that age, gender, years of service and

student classification have no significant impact on one's innovation potential; although, these factors may have a slight influence on one's innovation capabilities. They tend to balance out each other. For example, knowledge and experience may lead to quicker and better identification of innovation potential, but may also limit it as ideas are too quickly evaluated and discarded. In contrast, students may more easily follow crazy ideas that may lead to innovation while having a reduced success rate. Most differences discussed can be attributed to sample bias. Additional samples with different group mix are needed to analyze the results further.

## VI. THE 5GS AND THE I5 SCORE

The i5 Score results show that the score fits all 5Gs traits for faculty and staff, but shows some bias for students' data. The score is able to identify the innovation classes very well and could act as an assessment for innovative potential. Additional samples are needed to analyze this further. In addition, there is a bias in the faculty and staff data as none of the participants identified themselves as laggard. This reduced the effective innovation classes to four instead of five. Looking at students results, four out of five times laggards had a higher score than late majority. This may indicate that the two innovation classes for this sample subset are too close to each other and that additional testing is needed to separate the two classes.

## VII. CONCLUSION

The study shows that the i5 Score is a good measure of potential innovation in individuals and organizations. To succeed, one must have high levels of Grit and Grace combined with the ability to Generate and Give while maintaining a strong sense of Growth at all stages of life and development. In addition, our data show the following:

- a. Innovation happens everywhere from students and faculty to staff and administrators. It is largely independent of role, class or years of service with a slight bias in the early days.
- b. Men and women are equal at innovation. In some cases, women may be more innovative than men of the same rank, role and years of service.
- c. Innovation is independent of age. Young and old minds are hard wired for innovation. It is the growth mindset that sets apart higher innovators from others.
- d. Years of service may have a slight impact on innovation capacity however it is largely unaffected by years of service if the individual and organization has a high capacity for growth and openness.
- e. Learners of all classifications have a great capacity for innovation, however data show a slight bias toward the middle years for a higher potential for innovation.

## VIII. FUTURE WORKS

Additional studies of both academic institutions, industry professional and the general public are planned. In particular,

we plan to study medical professionals and pre-med students and compare their results to STEM and engineering professionals and students. In addition, we plan to deploy a public study with sampling of individuals in the public sector, non-profits, government, academia, service and high tech industry. Furthermore, it would be reasonable to conduct a long-term study at Florida Polytechnic University, to evaluate the innovative potential and its change over time. All of these studies will help to further evaluate and sharpen our framework.

The authors also envision the creation of a digital assistance that helps individuals foster their innovation traits and grow it to the next level. This is envisioned as a smart app and a backend service that takes advantage of graph databases and intelligent sensing to continually compute one's innovation score in real-time.

## ACKNOWLEDGMENT

The authors would like to thank President Randy Avent and the Office of the President at Florida Polytechnic University (FPU) for their support. Special thanks to Mr. Kevin Calkins and Ms. Jhohana Infante from FPU's Institutional Research Office for their assistance with the study instrument and suggestions for improvements. We are grateful to the faculty, staff and students at FPU for their participation in the study. We also would like to acknowledge our reviewers from FPU, sister universities in Florida including University of Florida, Florida State University, Florida Institute of Technology, and industry reviewers from Harris Corporation, IBM and others for their valuable comments and suggestions. Lastly, special thanks to our family for their support during the summer with many nights spent writing and analyzing the data.

## REFERENCES

- [1] Merigó, J.M., Cancino, C.A., Coronado, F. (2016), Academic research in innovation: a country analysis, *Scientometrics*, 18 (2), <https://link.springer.com/article/10.1007/s11192-016-1984-4>.
- [2] Online Search (2017a), Online search for term "Innovation": Google: About 648,000,000 results; Google scholar: 3,710,000; CiteSeerX: 901,770; MS academic search: 50000+. August 2017.
- [3] Online Search (2017b), Online search for term "Innovation research": Google: About 445,000 results; Google scholar: 218,000; CiteSeerX: 624,689; MS academic search: 14534. August 2017.
- [4] Online Search (2017c), Online search for term "Innovation traits": Google: About 1,740 results; Google scholar: 161; MS academic search engine: 63 results. August 2017.
- [5] Gartner (2018), Eye on Innovation Award, <http://www.gartner.com/technology/eye-on-innovation-awards/financial-services/> (checked on 01/05/2018).
- [6] Gartner (2017), Innovation Insight for Deep Learning, <https://www.gartner.com/doc/3579022/innovation-insight-deep-learning> (checked on 01/05/2018).
- [7] Gartner (2016), Innovation Insight on Digital Experience Monitoring, <http://www.gartner.com/imagesrv/media-products/pdf/Catchpoint/Catchpoint-1-3JWS1BM.pdf>.
- [8] Forrester (2017), Innovation Research, <https://www.forrester.com/Innovation#> (checked on 01/05/2018).
- [9] Research on Innovation, About, <http://www.researchoninnovation.org/index.html> (checked on 01/05/2018).
- [10] European Commission (2018a), Research and innovation, [https://ec.europa.eu/info/research-and-innovation\\_en](https://ec.europa.eu/info/research-and-innovation_en) (checked on 01/05/2018).

- [11] European Commission (2017), Open Science, <https://ec.europa.eu/research/openscience/index.cfm> (checked on 01/05/2018).
- [12] European Commission (2018b), Horizon 2020, <https://ec.europa.eu/programmes/horizon2020/en> (checked on 01/05/2018).
- [13] Salampasis, D., Mention A.-L. (2017), Open Innovation: Unveiling the Power of the Human Element, World Scientific Publishing Co. Pte. Ltd..
- [14] Dyer, J., Gregersen, H., Clayton, M. (2009), The innovators DNA, HBR, <https://hbr.org/2009/12/the-innovators-dna>.
- [15] Chan, W.-C., Chen, P.-C., Hung, S.-H., Tsai, M.-C & Chen, T.-K. (2017). Open Innovation and Team Leaders' Innovation Traits. *Engineering Management Journal*, 29(2), <http://www.tandfonline.com/doi/full/10.1080/10429247.2017.1309629>.
- [16] Kavadias, S. (2015), Enterprise Innovation: 6 degrees of innovation: traits driving business success in Asia, <http://insight.jbs.cam.ac.uk/2015/enterprise-innovation-6-degrees-of-innovation-traits-driving-business-success-in-asia> (checked on 12/28/2017).
- [17] Patterson, F., Zibarras, L.D. (2017), Selecting for creativity and innovation potential: implications for practice in healthcare education, *Advances in Health Sciences Education: Theory and Practice*, 22(2), <https://link.springer.com/content/pdf/10.1007%2Fs10459-016-9731-4.pdf>.
- [18] Ahmad, A., Ahmad, R., Hashim, K.F (2016). Innovation traits for business intelligence successful deployment. *Journal of Theoretical and Applied Information Technology*, 1589, [https://www.researchgate.net/publication/305640574\\_Innovation\\_traits\\_for\\_business\\_intelligence\\_successful\\_deployment](https://www.researchgate.net/publication/305640574_Innovation_traits_for_business_intelligence_successful_deployment).
- [19] Philips, J. (2012), Unusual Suspects, Identifying High Capacity Innovators in your organization, <https://ovoinnovation.files.wordpress.com/2012/07/unusual-suspects-final.pdf> (checked on 01/05/2018).
- [20] Kleinberg, T. (2017), 9 traits of highly innovative people, <https://www.linkedin.com/pulse/9-traits-highly-innovative-people-chad-mcallister-phd> (checked on 01/05/2018).
- [21] Freiberg, J. (2014), Why Innovation Is Everyone's Job, With Dr. Jackie Freiberg, author of Do Something Now: Be the One Who Makes Something Happen (Audio Podcast), retrieved from , <https://www.3pillarglobal.com/insights/innovation-everyones-job-dr-jackie-freiberg>.
- [22] Dyer, J., Gregersen, H. (2011), Begin to Think Different(ly), HBR, <https://hbr.org/2011/09/begin-to-think-differently>.
- [23] McAllister, C., 9 Traits of Highly Innovative People <http://innovationexcellence.com/blog/2017/02/08/9-traits-of-highly-innovative-people/>.
- [24] Wessley, T. (2014), 8 Traits of High-Performing Innovation Cultures, <http://blog.spencerhall.com/blog/bid/372030/8-Traits-of-High-Performing-Innovation-Cultures> (checked on 01/05/2018).
- [25] Duckworth, A. (2016), *Grit: The Power of Passion and Perseverance*, 2016. Scribner; ISBN: 978-1501111105.
- [26] Pink, D. (2011), *Drive: The Surprising Truth About What Motivates Us*, Riverhead Books; ISBN: 978-1594484803.
- [27] Gates, B. Sr. (2010), *Showing Up for Life: Thoughts on the Gifts of a Lifetime*, Crown Business; ISBN: 978-0385527026.
- [28] Kegan, R., Lahey, L. L (2000). *How the Way We Talk Can Change the Way We Work: Seven Languages for Transformation*. Jossey-Bass; ISBN: 978-0787955359.
- [29] Hruška, D. (2014), *Radical Decision Making: Leading Strategic Change in Complex Organizations*, Springer; ISBN: 978-1137492302.
- [30] Goldman, R., Gabriel, R.P. (2005). *Innovation Happens Elsewhere: Open Source as Business Strategy*, Morgan Kaufmann; ISBN: 978-1558608894.
- [31] Dweck, C.S. (2006), *Mindset: The New Psychology of Success*. Random House; ISBN: 978-1400062751.
- [32] Kegan, R (2009). *Immunity to Change*. Harvard Business Press; ISBN: 978-1422117361.
- [33] Romo, V. (2017), Obama Calls On Congress to Have 'Courage' On Health Care, <https://www.npr.org/2017/05/08/527378943/obama-calls-on-congress-to-have-courage-on-health-care> (checked on 01/05/2018).
- [34] Rogers, E.M. (2003), *Diffusion of Innovations*, Free Press, 5th edition, ISBN: 978-0743222099.
- [35] Moore, G.A. (2014), *Crossing the Chasm*, Harper Business, 3rd edition, ISBN: 978-0062353948.