Board 420: Using a Situational Leadership Framework to Understand the Role of Mentors in Cultivating Innovative Thinking Skills in STEM Education

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Sadan Kulturel-Konak is a professor of Management Information Systems and the director of the Flemming Creativity, Entrepreneurship and Economic Development (CEED) Center at Penn State Berks. She received her Ph.D.in Industrial and Systems Engineering (Auburn Univ.)

Dr. Abdullah Konak, Pennsylvania State University, Berks

Dr. Abdullah Konak is a Distinguished Professor of Information Sciences and Technology at the Pennsylvania State University, Berks. Dr. Konak also teaches graduate courses in the Master of Science in Cybersecurity Analytics and Operations program at the College of Information Sciences and Technology, Penn State World Campus. Dr. Konak's primary research interest focuses on modeling, analyzing, and optimizing complex systems using computational intelligence combined with probability, statistics, data sciences, and operations research. His research also involves active learning, entrepreneurship education, and the innovation mindset. Dr. Konak's published numerous academic papers on a broad range of topics, including network design, system reliability, sustainability, cybersecurity, facilities design, green logistics, production management, and predictive analytics. He has been a principal investigator in sponsored projects from the National Science Foundation, the National Security Agency, the U.S. Department of Labor, and Venture Well.

Chithra Adams, VentureWell

Chithra Adams serves as the Director of Learning and Evaluation at VentureWell. She has close to two decades of experience in program evaluation. VentureWell evaluation team conducts evaluations of entrepreneurship training programs, course and program grants, and STEM accelerators. Dr. Adam's research interests include understanding of behaviors exhibited during the innovation process. She has a Master's Degree in Public Administration and a Doctoral Degree in Educational Sciences from the University of Kentucky.

Miss Alexa Joelle Prince

Alexa Prince is a second-year student at Penn State University studying Business Management. She is involved in undergraduate research in Innovative Thinking Skills.

Prof. David Robert Schneider

David R. Schneider graduated from Rensselaer Polytechnic Institute in chemical engineering in 1999, attended Columbia University Film M.F.A. Program in 2001, and earned his master's and Ph.D. from Cornell University in mechanical engineering with a concentration in controls & dynamics in 2007. David has taught at both Columbia University, where he was the highest student-rated instructor in the College of Engineering, and at Cornell University where he is now the Director of M.Eng. Studies for Systems Engineering, the largest M.Eng. program at Cornell.

As a faculty member in systems engineering, David has focused largely on industry collaborations, advising over 1200 professional M.Eng. students, and over 1000 students overall on student projects with companies and government agencies that have ranged from Intel, Lockheed Martin, ARM, Carrier, US Green Building Council (USGBC), Applied Materials, MOOG, SRC, Altera, Boeing, Smithsonian, Hasbro, Autodesk, MathWorks, L-3, MITRE, Da Vinci Labs, JPL, Air Force Research Labs, Marine Corps, NSF, M-E Engineers, NASA Ames, Goddard, & Kennedy, and more, where most projects have lead to real world implementations and/or are being developed with Cornell Technology Licensing. Some of the David's favorites include:

* Creation of the Cornell Cup USA presented by Intel, now the Cornell Cup – Arm Enabled, international embedded systems competition * Cape Canaveral AFS / NASA Kennedy collaboration Minotaur Launch Vehicle Feasibility Study, turning minotaur missiles into low orbit launch vehicles and leading to successful launch of the OSR-5 satellite * Unmanned Aircraft Evasive Maneuver Mission Re-planning Algorithm Development with MITRE * Taiwanese Disaster Recovery Plan Modeling with Lockheed Martin * New Product Development Process Re-design with Applied Materials * R2-D2-inspired Lab Assistant Droid and C-3PO-inspired Telepresence Walking Droid showcased to top members of the Obama White House Office of Science and Technology Policy, at NASA Kennedy Space Center, the NYC Hall of Science, and Walt Disney World

With a strong focus on education, David created the first experience in the world recognized by the systems engineering professional society INCOSE as knowledge exam equivalent, and the only person to have created now two experiences earning this honor. Additionally, David created and runs the systems engineering courses for Lockheed Martin's largest Engineering Leadership Development Program. David's main course, Model Based Systems Engineering, is also now officially sponsored by Boeing. David has also received multiple recognitions for his educational work from the Obama White House Office of Science and Technology Policy and was an invited guest for the official start to the National Week of Making and the CS4ALL initiatives. David also led the broader impacts video game creation for the NSF Expeditions in Computing Grant on Computational Sustainability and is the head faculty advisor for Cornell Cup Robotics and Cornell University Sustainable Design (CUSD), which is commonly Cornell's largest and most diverse student project team. David was also a screenwriter for Walt Disney Attractions Television Production.

Research Interests: David Schneider's research has traditionally focused on the realm of NP-Hard Computer Science Problems and Controls for Robotic Systems in both centralized & decentralized and autonomous & semi-autonomous systems. His most prominent research is his creation of the G*TA (G-Star-T-A) task allocation algorithm and his work as program manager of the Cornell RoboFlag program, with notable applications including AFRL UAV controls and NASA/NOAA unmanned boat designs. Aside from his work at Cornell, David also values his time dedicated to this area while at NASA Goddard as a team lead in Code 88 Advanced Automations & Architectures.

Most of David's career at Cornell has focused on collaborative projects and research with industry, or even in support of Cornell initiatives. Some of David's favorites include:

* Remote Occupancy Sensing HVAC controls system with M.E. Engineers Architectural consulting firm as well as recently Blackstone's $448,000,000,000 Global Real Estate Portfolio * Sunn Hybrid Lighting Project sighted as a top project in the nearly 20 year history of the EPA P3 grant and became a successful student start-up company * Cold Climate Greenhouse Research examining low energy and mixed aquaculture/hydroponics, which raised funding for the creation of new experimental greenhouse on Cornell's main campus, with a partnering world-wide 70 pilot site collaboration * Investigating novel sustainability and alternative energy generation options for the proposed Cornell Tech Campus on Roosevelt Island in NYC with CUSD and being the only student project group recognized and thanked by Cornell President Skorton in letter to the alumni on Cornell's ˜$500,000,000 Tech Campus proposal win over Stanford. Then being highlighted in the opening plenary talk of Greenbuild with USGBC CEO and President Rick Fedrizzi for related work. * Disney-Inspired Star Wars Pod Racing Theme Park ride with MOOG for the development of a VR plus 6DoF Motion Platform, cited as being the first successful combination of VR and a 6DoF motion platforms

David is also dedicated to STEM and particularly engineering education R&D since even his early career with publications in journals such as the International Journal of Engineering Education—Active Learning Special Edition and being the key developer of the broader impacts on grants like the NSF Expeditions in Computing Grant on Computational Sustainability. Stemming from his involvement in the Obama CS4ALL initiative, David also developed a means of assessing computer science educational programs against the Computer Science Teacher Association's K-12 standards as well as informing students, teachers, and parents on a student's computational thinking learning progression. David continues to be dedicated to this R&D area and has developed a computer science focused educational robot to rival

Lego Mindstorms, Vex & MakeBlock that has been licensed thru Cornell Technology Licensing to Educational Technologies. Most recently, David is also a Co-PI on the NSF "Cultivating Innovative Thinking Skills in STEM Education" grant investigating the education benefits of college student project teams and competitions.

Teaching Interests: David Schneider has dedicated much of his career towards the improvement of engineering education. In addition to mentoring typically over 200 students every semester on many of the projects listed above, David has taught courses such as Model-Based Systems Engineering, Engineering Project Leadership, and Creativity in Engineering. Through the Cornell Cup, David has also developed in conjunction with the Cornell team's students, a series of systems engineering professional design guides that target identified nationwide curriculum gaps. Utilizing this work in particular, students have earned such recognitions as being the 1st American team to win the James Dyson Award for Engineering Design, one of America's "30 Under 30", and even quoting the guides when being featured on NBC as one of the top six "College Inventions Everyone Should Be Aware Of".

These guides have been used by students and faculty around the world including from: U. Akron, ASU, Berkeley, Boston U., UC Davis, UC San Diego, Carnegie Mellon, U. Colorado Denver, Columbia, Duke, U. Florida, Florida Inst. of Tech, Georgia Tech, U. Houston, Howard, U. Illinois at Urbana-Champaign, John Hopkins, UMass Amherst, UMass Lowell, U. Michigan, MIT, Oklahoma State, Oregon State, UPenn, Penn State, U. Pittsburg, Portland State, Purdue, RIT, U. Rochester, RPI, Seattle Pacific, Southern Illinois University at Carbondale, Tufts, USC, Vermont Tech, Virginia Tech, WPI

David has received numerous recognitions for his work in this area, including recognition from the Obama White House Office of Science and Technology Policy where his work was cited as one of seven university efforts in the White House Fact Sheet of Making in 2015 and again in 2016 as one of nine university efforts out of 1,500 university and K-12 efforts seriously considered.

As a member of the Cornell Faculty Institute for Diversity, David also leads what is commonly the largest and most diverse student team on campus, Cornell University Sustainable Design (CUSD), as well as Cornell Cup Robotics, both of which are often led by a majority of female students.

David also co-founded the NASA Robotics Alliance Cadets program with Mark Leon, NASA AMES Director of Education and David Lavery, NASA Program Executive of Planetary and Solar Exploration. David has also served on a number of educational committees and panels including being a guest expert on the "America's Favorite Maker" TV show. David has led the efforts to make Cornell the first university to officially partner with Make:. With Make: David led the re-creation of the national entrepreneurial competition "Pitch Your Prototype". David also was the leading faculty member behind the American Society of Engineering Education, Community Engaged Division Film Festival national competition. As one who has always sought to embody Cornell's "Doing the Greatest Good…" initiative, David with Cornell Cup Robotics is also currently mentoring the Afghan Dreamers, the all-girls robotics team from Afghanistan, thanks to a collaboration with the Afghan Dreamers parent organization the Digital Citizen Fund.

Prof. Khanjan Mehta

Khanjan Mehta is the inaugural Vice Provost for Creative Inquiry and Director of the Mountaintop Initiative at Lehigh University. Mehta champions the creation of integrated learning, research, and entrepreneurial engagement ecosystems where students, faculty, and external partners come together to increase their capacities for independent inquiry, take intellectual risks and learn from failure, recognize problems and opportunities and effect constructive and sustainable change. Mehta is the prime instigator for four signature academic programs – the Mountaintop Summer Experience, the Global Social Impact Fellowship, the Lehigh Valley Social Impact Fellowship, and the Campus Sustainable Impact Fellowship that engage faculty and students in ambitious, interdisciplinary, multi-year, impact-focused ventures.

Using a Situational Leadership Framework to Understand the Role of Mentors in Cultivating Innovative Thinking Skills in STEM Education

Abstract

Like many faculty, we have organized student innovation competitions and programs (ICPs) and coached many student teams for various competitions; therefore, we have observed first-hand how transformational the experience has been for our students. ICPs allow students to quickly test their skills and knowledge, push them beyond their comfort zones, encourage them to take risks, and provide a safe place to try and fail, as failures can be seen as a critical part of the learning process [1]. Despite their invaluable learning benefits, existing literature lacks a theoretical body of knowledge on the influence of ICPs on the educational experience. Our goal is to explore transformations in students' mindsets toward innovation through perspectives and data from students who formerly participated in ICPs, mentors who coach students through ICPs, and ICP organizers who create these opportunities for students. This paper will focus on the essential practices of mentors.

Methodology

This study used the interview method to gather responses from thirty mentors from select universities across the Northeastern and Midwestern United States with experience in student ICPs. The collected data has gone through preliminary rounds of qualitative data analyses, and initial conclusions have been drawn to garner a series of best mentoring practices. Interview questions touched on several areas, including personal mentor experience, motivation and practices as a mentor, structure of innovative programs, impacts and challenges of student ICPs, and suggestions to improve the student experience. Interviews were conducted remotely via video conferencing by two research team members, who were trained with uniform interview objectives and skills. Interviews were conducted independently at scheduled times and varied from 20-40 minutes in length. The complete recordings of the interviewee responses to these questions were transcribed into text and underwent an initial coding of analysis. We then focused on analyzing our interviewed mentors' responses to the following question: What are some of your best mentoring practices? The responses to this question were analyzed and developed to create a set of best mentoring practices.

We used a bottom-up approach (inductive coding) to analyze the interview transcripts. First, each research team member was assigned to a random subset of the transcripts, and at least two research team members reviewed each transcript. Then, the research team members independently identified core concepts emerging in their assigned transcripts, and these identified concepts were merged into the final codes during a consensus-building session.

Finally, three research team members reviewed all 30 transcripts independently and marked whether the codes existed in the transcripts or not (leading to a 78.6% agreement on the codings).

Findings

We identified common mentoring styles by clustering the codes based on how frequently they appeared together in the transcripts. The mentoring practices could fall under four categories—Reality checks, goal orientation, project management, and people connectors. The interview results indicate that because ICPs require students to transform an idea into a compelling solution to a pressing problem, mentors need to use a varied set of contextually dependent practices.

First, we identified common mentoring styles (themes) by clustering the codes based on how frequently they appeared together in the transcripts. Figure 1 presents a horizontal dendrogram where the frequently appearing codes are clustered together on the same branch, and different codes are further apart. There happened to be five styles emerged from our mentor interviews. The first mentoring style focused on giving students honest and critical feedback (*Reality Checkers*). Another group of mentors emphasized supporting students in terms of project management (*Project Managers*). The Project Managers cluster was closely related to themes about supporting students to understand the big picture and have a clear vision of their final products. We call this group *Goal Oriented*. Mentors suggested they could advise and guide students better once they understand their mentees' backgrounds and expectations. Another emerging mentoring style involved a focus on providing students with emotional support, i.e., *Emotional Coaching*. Since student competitions may require considerable time and effort, Emotional Coaching is important for retaining students in these programs and ensuring they complete the program successfully. The remaining codes appeared closely under two concepts, although they were conceptually different, i.e., "*People & Ideas Connectors*." Helping students be aware of and connect to resources in innovation ecosystems is an essential mentoring role for student innovation teams to be successful.

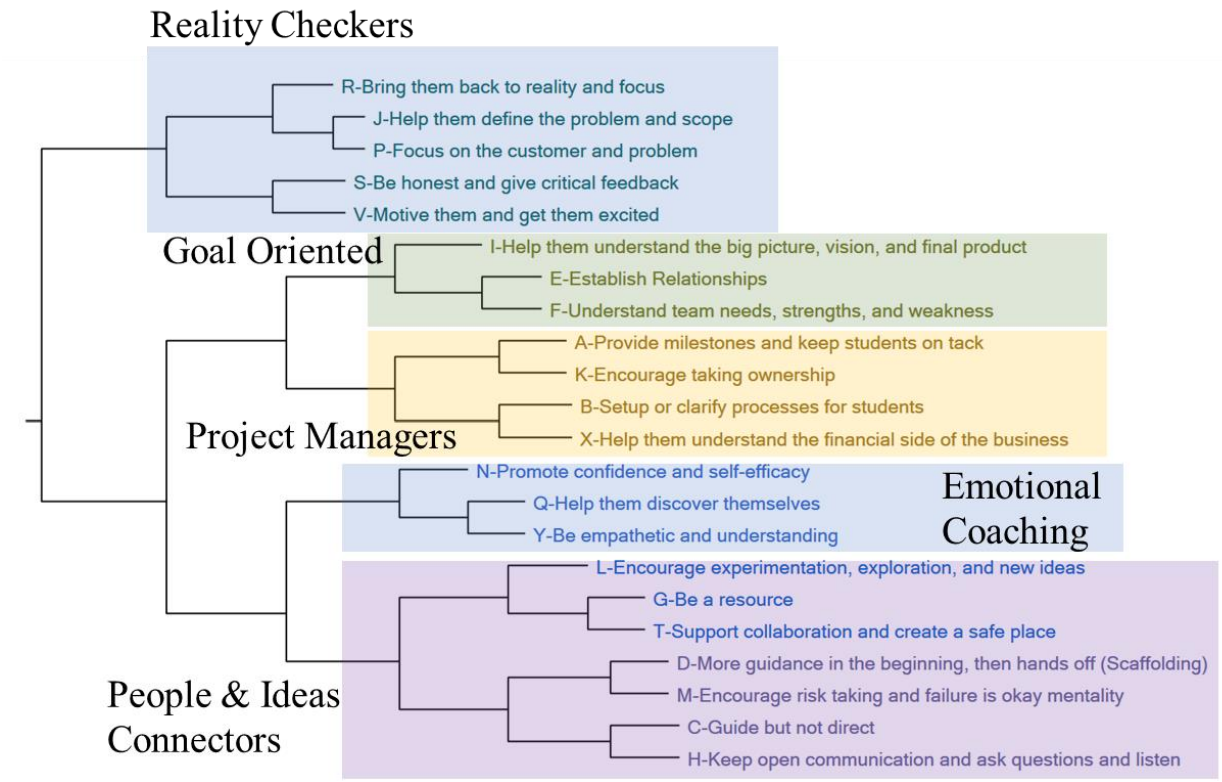

Figure 1. Cluster analysis of the emergent codes and themes.

ICPs also provide an opportunity for students to receive intense mentoring on high-pressure problem-solving. ICPs, by design, provide students an opportunity to learn through mentor relationships and program activities to become self-directed thinkers. Using a situational leadership framework ([2], [3]), we will explore the critical mentoring practices gained through the ICP process --directive practices (project management and goal-oriented) and supportive practices (emotional coaching, people connectors, reality checkers). We will discuss how the situational leadership lens makes explicit the tacit learning that is gained through the mentor-mentee relationship. Since mentoring involves mentees self-regulating behavior, attitudes, and emotions [4] and applying their knowledge in different contexts [5], we will show that the situational leadership lens provides a framework that connects the context to the behavior. The situational leadership lens will also be shown to provide a mental model to understand why a directive or supportive practice is appropriate for a particular context. Finally, it will be shown that mentees can use the mental model beyond STEM innovation and have a framework to use in their professional careers.

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