



ENGAGING LEARNERS IN CYBERSECURITY CAREERS: LESSONS FROM THE LAUNCH OF THE NATIONAL CYBER LEAGUE

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Educators and sponsors endorse competitions as a strong, positive influence on career choice. However, empirical studies of cybersecurity competitions are lacking, and evidence from computer science and mathematics competitions has been mixed. Here we report initial results from an ongoing study of the National Cyber League to provide a glimpse of the role of competitions in fostering cybersecurity career engagement. Preliminary results suggest that cyber competitions attract experienced individuals who will remain in the profession for the long-term, but future research is needed to understand how cyber competitions may engage women and those new to the field.

Millions of dollars in federal and private investment have been spent on the development of competitions such as CyberCIEGE from Naval Postgraduate School; CyberPatriot sponsored by the Air Force Association using CyberNEXS developed by SAIC; CyberLympics developed by EC Council; Cyber Quest and NetWars developed by The SANS Institute; DC3 Digital Forensics Challenge from the DoD Cyber Crime Center; and Panopoly developed by University of Texas, San Antonio. Some educators and sponsors endorse cyber competitions as a strong, positive influence on career choice for several reasons. First, the competitions may increase the awareness of the meaningful and challenging work performed by cybersecurity professionals that may lead to increased aspirations to pursue a cybersecurity career. Second, the competitions may help participants develop a sense of self-efficacy in performing the work [2]. Third, the combination of meaningful work, and a belief in developing competence, can create a sense of empowerment that has been associated with conversion of vocational interest into an intention to pursue a career. Finally, competitions may provide challenges that are well aligned with a person's ability, thereby encouraging emotional involvement in autotelic activity that indicates engagement in a profession [10].

Empirical studies of the effectiveness of cybersecurity competitions is lacking, and evidence from computer science and mathematics competitions yielding increased interest in STEM careers

has been mixed. Some case studies of immersive educational simulations support the view that hands-on activities engage the participant, and in doing so, facilitate situational learning and transfer of skills to the real-world [5]. However, in other cases competitions may have the opposite effect. The anxiety caused by the failure to win may engender doubts about the ability to perform well in the profession. For example, in a study of Second Life as an immersive education simulation tool, Cooper [4] found that simulation systems only led to engagement when the participant's skill level was already high. These results suggest that competitions may only be effective for students with existing skill sets that closely match those required by the competition. Rather than increasing engagement in cybersecurity careers for larger numbers of students, competitions may only assist in enhancing the interest of those select few who have already developed reasonably high levels of skill. Furthermore, studies of interest, developed in other STEM disciplines through hands-on activities, suggest that cyber competitions may have limited impact on fostering career interest or altering career intentions [8].

Participation is one way to measure the participant awareness and interest in cybersecurity competitions and careers. The number of students participating in cybersecurity competition and challenge programs are growing exponentially, providing some support for claims that they are increasing the numbers

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of students interested in pursuing cybersecurity careers. For example, in the recent past usage of the CyberPatriot environment has tripled – expanding from 200 five-student teams across 44 states in the academic year 2009-10 to 650 teams in 48 states and 3 U.S. territories in 2010-11. These numbers demonstrate an encouraging increase in the number of students who are interested in developing the skills necessary to compete at the national level.

Despite the rapid expansion of cybersecurity competitions, studies of effectiveness have been primarily qualitative.

Despite the rapid expansion of cybersecurity competitions, studies of effectiveness have been primarily qualitative [3,11,12]. Furthermore, it is unknown how many participants have returned to compete each year. Evidence of repeated individual, or team participation, could provide evidence of engagement and retention of students in the field as a whole. Although anecdotal evidence suggests that competitions may be a positive approach to providing enriched, authentic learning experiences and identifying talent, we lack systematic empirical analysis of the role of cybersecurity competitions for increasing awareness, interest, and engagement in cybersecurity careers. In summary, despite substantial investment in cybersecurity competitions and a belief in their effectiveness in growing the cybersecurity workforce pipeline, we lack an understanding of how these programs affect occupational interest and professional engagement.

The structure of cybersecurity competitions further limits our understanding how competitions may impact the development of occupational interest and professional engagement. Most competitions exist as isolated, one-time events; so, we lack the ability to follow students as they progress. A single annual event also means that few competitions provide an ongoing practice environment with detailed individual feedback. Frequent practice may be necessary to develop student skills and could increase interest and engagement in the profession. Consequently, in 2012 several NSF Advanced Technological Education Centers collaborated to launch the National Cyber League (NCL), which provides weekly competitions leading to an NCAA March-Madness style playoff system and a national championship. The design of the NCL competitive season supports a longitudinal study of developmental processes such as professional engagement. Here we report initial cross-sectional results from the ongoing study of NCL participants to provide a glimpse of the role of competitions in fostering cybersecurity career engagement among participants.

CAN COMPETITION ENGAGE STUDENTS IN CYBERSECURITY CAREERS?

Ultimately, the goal of cybersecurity competitions is to fill the pipeline to cybersecurity careers with well-trained individuals who will remain working in the field for the long-term. These characteristics describe the term professional engagement. Experts in the field of career engagement define the term as a “positive, fulfilling work-related state of mind that is characterized by vigor, dedication, and absorption [14:710].” The three dimensions, vigor, dedication and absorption, are positively associated with individuals who demonstrate a persistent and enduring enthusiasm for work and display tenacity in the face of work-related challenges. Understanding the engagement of participants in the NCL can provide us with an indication of the capability of cybersecurity competitions to identify and develop skilled

individuals who are committed to careers in the cybersecurity field.

The participants of the fall 2012 NCL competitions were students currently enrolled at accredited U.S. community colleges or 4-year colleges/universities. Eighty-five percent of the participants were male. We do not have an accurate breakdown of gender for the cybersecurity professions, but it is known that women hold about a 24% share of all science, technology, engineering and mathematics (STEM) jobs and specifically information technology jobs [1]. This disproportion suggests that gender inequity exists among all STEM and computer related fields. Consequently, growth of the cybersecurity workforce could dramatically increase by encouraging participation of women in cybersecurity careers.

Our exploratory study of NCL adapted the Utrecht Work Engagement Scale (UWES-9) to measure engagement among participants of the NCL competitions in the fall of 2012. This instrument was used because the UWES-9 has been established as a valid and reliable measure of engagement among individuals from diverse nations, racial, occupational backgrounds irrespective of gender. The nine-question, Likert-type scale items ask participants to rate a statement about how they feel at work. The researchers edited each statement to read, “while participating in the competition” rather than “at work.” Participants could choose from a minimum rating of 0, “Never”, to a maximum rating of 6, “Always/ Every Day.” Participants rated three statements with indicators that relate to each of the three dimensions. For example, the dimension of vigor was assessed with the statement “while participating in the competition I feel bursting with energy.” The nine indicators of career engagement can be generally described by the way competing makes them feel. The dimension of dedicated indicators include 1) inspired, 2) enthusiastic, and 3) proud. Absorbed indicators are 4) carried away, 5) immersed, and 6) happy. And vigorous indicators are 7) bursting with energy, 8) strong and vigorous, and 9) feel like participating in the competition. In order to understand the role of engagement among competition participants, the three dimensions of engage-

ment were compared for participants who indicated the NCL competition was their first against participants who had participated in more than one cybersecurity competition (NCL or not).

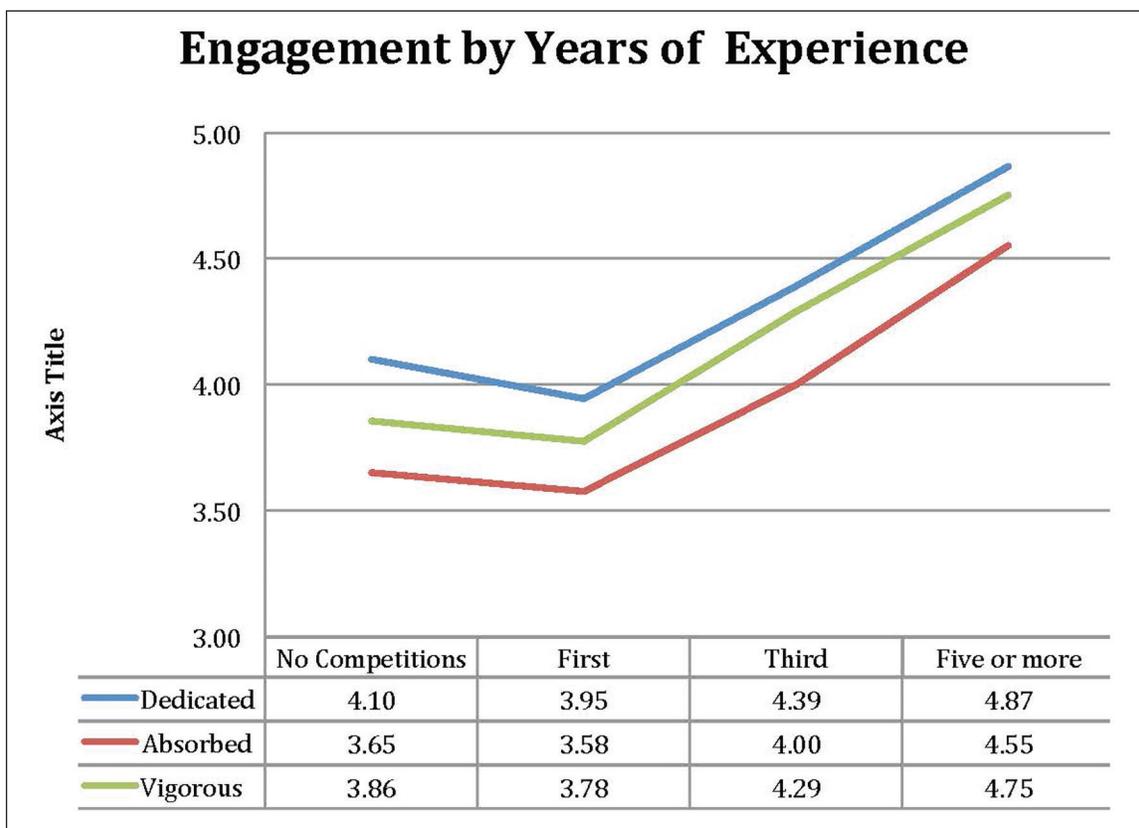
The 2012 fall NCL season included three competitions—each of which was open to new participants, creating variance in the number of new teams and individuals competing during each competition. This also meant that the number of first time participants varied by competition. Of the 547 surveys analyzed, about 45% of the students who competed in the first competition completed the entire season of all three competitions. Additionally, each subsequent competition included fewer novice (first time competition) participants. The first competition included 127 novices, which decreased to 105 for the second competition, and finally 70 in the third competition.

Overall, engagement appears to be changing as competition experience increases, though range restriction and the sample size limit the power to detect statistically significant differences. Figure 1 graphs the three dimensions of engagement by experience level of the participant. The level of engagement reported by novice participants in the fall 2012 NCL competitions was less than that reported by experienced participants, though both groups reported generally high levels of engagement. Differences were statistically significant for only two of the components of engagement (Proud and Carried Away) with a p -value $\leq .05$. Although the survey was cross-sectional, involvement of students with varying degrees of experience suggests how engagement may change over time. Two trends seem interesting and worthy of further study. First, there is an initial drop in engagement after participating in their first competition, most notable in the level of dedication towards pursuit

of professional activities. The reduced dedication may explain the drop in first-time participants reported above. Second, engagement across all dimensions appears to improve as experience increases. However, the study design precluded determining whether competitions lead to increases in professional engagement, or whether competitions are simply more effective at attracting students who already feel more engaged in pursuing a cybersecurity career.

The greater mean subscale score among experienced participants suggests that experienced participants are more engaged than the novice participants are. However, the decreasing number of novice participants could explain this trend. The UWES-9 holds several psychometric properties which include that subscales are “internally consistent and stable across time” [13:41]. Therefore, if experienced participants report more intense engagement scores, their UWES subscale scores would dominate the means as fewer novice participants are represented.

This is an important concern for educators and sponsors of cybersecurity competitions. The substantial drop-off in novice participants across the three events represents those individuals who have just begun to enter the field. The growth of participation in competition events are generally presumed to be increasing the number entrants into the field. The analysis of the NCL data indicates that competitions may actually be constraining or detracting from this growth. It may be possible that competitions discourage those with little prior experience in cybersecurity. At a minimum, this analysis seems to strongly suggest more research is needed to understand the difference in change to perceived engagement between those with little to no experience and those who are entering their second (or greater) competition.




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A STEP IN THE RIGHT DIRECTION

There is little argument that the key to improving the economic and physical security of our nation begins with a highly trained and motivated cyber-savvy workforce. Cybersecurity competitions provide competitors a chance to practice and hone their skills in authentic environments. The NCL training and competition structure provided an opportunity for us to examine the role of engagement among novice and experienced participants. The results of the study of the 2012 fall pilot season suggest that this cyber competition attracted participants who were engaged in the competitive activity. The UWES-9 norms indicate that most individuals engaged in their profession will report means similar to the results of this study. This is an indication that cyber competitions attract individuals who will remain in the profession for the long-term.

This finding is supported by decades of research on occupational choice. An important psychosocial variable that is a strong predictor of career choice is an individual's choice of leisure activities [6,7]. Cybersecurity competitions extend the formal learning environment through a substantial leisure time commitment. Therefore, cybersecurity competitions may be better at attracting those already committed to the profession than interesting and developing those still exploring their interest.

Other findings of the study indicate hurdles that competitions have yet to conquer. Since only 15% of the participants were female, cybersecurity competitions may have difficulty filling goals for workforce pipeline growth. It is important that future research address not only the current competitors, but the non-competitors as well. We need to better understand the factors that encourage or discourage engagement in activities that will increase the occupational interest and skill development of talented youth.

Furthermore, the decline found in first time participants needs to be explored. It is possible that since this pilot season competition was open to a limited audience, the pool of novice students became exhausted. However, this would not explain why so many novices who competed in the first event elected not to compete in subsequent rounds. We can envision several investigative paths for future research. The NCL offers a preparatory environment so that participants may practice for the competitions in advance. An investigation should be made to determine the adequacy of this preparation. Further research might also explore how tasks involved in competitions map to established frameworks for assessing success in the profession [9,15]. Finally, it would be ideal to survey non-participants from the same collegiate programs to understand their participation or lack thereof.

In conclusion, the study of the NCL fall 2012 pilot season represents a single snapshot of the participants. The study provided valuable clues to the importance of cybersecurity competitions, but it also raises important questions about the role and effectiveness of

competitions in meeting the growing need for cybersecurity talent. These competitions attracted an engaged population who have the potential to remain in the profession for the long-term. Future work of this study will examine what factors impact the development of engagement over time, how these factors might affect the election by first-time participants to continue their involvement throughout the season or engage in additional competitions, and what might engage non-participants to consider entering a competition. These efforts will build a better understanding of the competitors and ways to attract more female and first time participants. ■

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