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Developing the Future Modeling and Simulation Workforce with the Skill Sets to be Competitive in a Global Environment

Henry C. Okraski
Chair, National Center for Simulation
Education & Workforce Development Committee
President/Chief Executive Officer
Henry C. Okraski and Associates, Winter Park, Florida

The issues surrounding the development of tomorrow's modeling and simulation workforce are addressed in the context of worker demand and existing student capabilities and performance in STEM. The forces acting on today's students are discussed, including student attitude, parental guidance and support, the changing technological environment, lack of student confidence and destructive "mind-sets". The Florida STEM/M&S Workforce Model is discussed including the four year curriculum for high school students and the planned M&S Certification program. STEM/M&S begins in elementary school where students get excited about the promise of involvement in interesting and challenging courseware, encompassing hands-on simulations. The high school curriculum, based on earlier work accomplished by Old Dominion University and enhanced by an industry, academia and government task force, is available on the National Center for Simulation website. Qualified teachers are greatly in demand. Certification offers advantages to the student, school and the simulation industry.

Background

Much has been written about the state of the United States science and technology talent in relation to other countries. The nation finds itself slipping in the quality and quantity of its engineers and scientists, and in response, the country has put considerable emphasis on Science, Technology, Engineering and Mathematics (STEM) education at all levels. At present, the position on the world's "report card" is unremarkable. The Programme for International Student Assessment (PISA) reports that out of the 65 countries participating in data collection, the United States students ranked 30th in mathematics, 23rd in science and 20th in reading. Those rankings do not bode well for such a wealthy and progressive nation.


Henry C. Okraski

Modeling and Simulation (M&S) is a national critical technology employing disciplines under the STEM umbrella. It is a rapidly growing technology with a myriad of applications including military, medical, transportation, entertainment, sports, etc. There are several centers of M&S throughout the country but the epicenter is in Central Florida where the military services perform research, acquire and support training systems for live, virtual and constructive training. In Central Florida, there are approximately 27,000 individuals, with an average annual salary of $70,000, working directly in M&S for the military. Add to it those employed in the entertainment and health care simulation industries and the figure becomes very large. M&S has become a large business, requiring a wide spectrum of skill sets.

M&S is being used in Test and Evaluation (T&E) to substitute, where feasible and cost-effective, for operational systems, sub systems, equipment, software and a wide range of functions. For example, adversary threats can be simulated in a weapons system rather than using live threats, testing the system in that mode. This holds true for live ranges and systems acquisition and operational testing. Testing (or evaluating) human performance in a simulated land combat battle was made possible through simulated live fire via the Multiple Integrated Laser Engagement System (MILES), invented by a Navy engineer, working for the Army and the technology transferred to the Marine Corps. Simulators present

unique testing challenges. Training simulators can be very complex, often more complex in hardware and software than the parent system (aircraft, ship, tank, submarine, etc.). Testing these very complex systems requires knowledge of not only the parent system but an understanding of the trainer-peculiar subsystems such as environmental simulation and its instructional functions.

The National Center for Simulation (NCS) recognized the need to develop a viable workforce with the necessary skill sets to support M&S and consequently embarked on a course to ensure that resources would be available to support the industry. It includes a high school curriculum, an industry certification program and an examination of teacher preparation to teach M&S. All of them are keyed to the Florida M&S pipeline model to be discussed later.

The Global Situation

The International College of Economics and Finance (ICEF) (ICEF Monitor) has some very interesting projections on where the United States is going as compared to other nations, summarized as follows: a) The expansion of higher education in rapidly-developing G20 nations has reduced the share of tertiary graduates from Europe, Japan and the United States in the global talent pool; b) If current trends continue, China and India will account for 40% of all young people with a tertiary education in G20 and Organisation for Economic Co-operation and Development (OECD) countries by the year 2020, while the United States and European Union countries will account for just over 25% and c) The strong demand for employees in "knowledge economy" fields (i.e., STEM) suggests that the global labor market can continue to absorb the increased supply of highly-educated individuals.

There are those who dismiss the current shortage of scientists, engineers and technologists, maintaining that there are large numbers of skilled people currently unemployed or working at jobs beneath their qualifications. This may be accurate today but as the global landscape changes with more innovative technology and demand for specialized skills, the workforce will not be in a position to respond to those rapidly-changing demands. New and improved skill- sets and increased numbers are necessary.

Forces acting on students in their career choices

Examining students in the United States reveals that they are subject to ever- changing forces, some of which have been very subtle. It is difficult for most youngsters to relate to engineers and scientists. Students rarely view any such persons on television or portrayed in the movies. The media tends to glorify sports and entertainment figures. Also, most students have first hand experiences with doctors, lawyers, plumbers, and many other workers and professions but do not see engineers and scientists practicing their profession. "What do engineers do?", they ask. Without any interaction with engineers, the youngster can only imagine what they do. They hear others say "engineering is too hard", coupled with "I don't understand or do very well in mathematics." These help to develop a negative attitude and rejects any consideration of STEM careers. Reinforcing this is the scarcity of role models in their every day lives. Teachers, for the most part, have little or no experience in science or engineering. With that as a backdrop, is there any wonder why students are not rushing to take STEM courses or pursuing STEM careers?

Additional forces act on the students, affecting their career decisions. These factors, other than test anxiety and difficulty, include student attitude, parental guidance and support, the changing technological environment, lack of confidence and destructive "mind-sets".

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Student attitude toward STEM

In 2011, the National Research Council called on educators to increase the number of students pursuing STEM career pathways after high school, including students from groups traditionally underrepresented in STEM—students of color, women, and students from low socioeconomic backgrounds. Experts on the President's Committee of Advisors on Science and Technology contend that improving the overall interest and attitude toward STEM among young students is as important as increasing the overall level of academic proficiency in STEM.

In a study by Malinda Faber (Faber), The Friday Institute for Educational Innovation at North Carolina State University, she proposes that K-12 and postsecondary students lack interest in STEM relative to the societal and labor market demands. For example, many high school and postsecondary students divert from STEM pathways and occupations into other fields. What is even more significant is that more than three out of four high school students who test in the top mathematics quartile do not pursue a STEM major in college. Additionally, of those who pursue STEM majors, only 50% actually complete their degree in a STEM area.

Results from the survey conducted by Faber showed that students had generally moderate interest in STEM careers. Somewhat surprising, the greatest proportion of students indicated that they were "interested" or "very interested" in veterinary work (51.4%), while the

smallest proportion of students reported that they were "interested" or "very interested" in careers in physics (29.8%). On average, female and male students expressed a similar level of interest in STEM careers as a whole (42.6% and 38.9% on average). When STEM career pathways were analyzed separately, however, female students had particularly low levels of interest in engineering, computer science, energy, and physics. For those four career pathways, female students had interest levels lower than a 30% proportion "interested/very interested," while there was not a single STEM field for which male students expressed interest levels lower than a 30% proportion. The differences in levels of interest in STEM careers between students of different races/ethnicities were smaller than the differences between male and female students. Asian students had the highest average level of interest in STEM careers (47.0%) and White/Caucasian students and Black/African American students had the lowest average levels (39.8% and 40.0% respectively).

Parental Guidance

Conventional wisdom says that parents must be involved in the student's development for the youngster to succeed in life. The redefinition of the family through social change has complicated the situation somewhat in that traditional roles and values are in flux and, as a result, quality study time with the student may not be a high priority universally. Recognizing the seriousness of the situation, the National Science Teachers Association (NSTA) has promulgated a policy on parent involvement as follows:

"The National Science Teachers Association (NSTA) believes the involvement of parents and other caregivers in their children's learning is crucial to their children's interest in and ability to learn science. Research shows that when parents play an active role, their children achieve greater success as learners, regardless of socioeconomic status, ethnic/racial background, or the parents' own level of education (PTA 1999; Henderson and Mapp 2002; Pate and Andrews 2006). Furthermore, the more intensely parents are involved, the more confident and engaged their children are as learners and the more beneficial the effects on their achievement (Cotton and Wikelund 2001).

Historically, innovations in science and technology have been powerful forces for improving our quality of life and fueling economic development worldwide. To continue to reap the economic and social benefits that accrue from such innovation, as well as to find solutions to challenging problems in the areas of health, energy, and the environment, we must ensure parents and children value science learning and recognize the tremendous opportunities that can arise from being more scientifically and technologically literate and better prepared to participate in the 21st-century workforce.

Parents and other caregivers have a critical role to play in encouraging and supporting their children's science learning at home, in school, and throughout their community. Teachers also play an important role in this effort and can be valuable partners with parents in cultivating science learning confidence and skills in school-age youth. NSTA recognizes the importance of parent involvement in science learning…"

Technology revolution

The digital revolution has changed all of our lives but perhaps, most significantly, students are faced with new and mounting challenges in the environment of real-time information and communications. Social media and instant messaging cause constant interruptions and result in loss of focus and concentration.

The New York Times reviewed findings from two reports on how technology is changing student's learning behavior. One was conducted by the Pew Internet Project, a division of the Pew Research Center that focuses on technology-related research. The other comes from Common Sense Media, a non-profit organisation in San Francisco that advises parents on media use by children. It was conducted by Vicky Rideout, a researcher who has previously shown that media use among children and teenagers ages eight to 18 has grown so fast that they on average spend twice as much time with screens each year as they spend in school.

In the Pew survey, which was done in conjunction with the College Board and the National Writing Project, nearly 90% of 2,462 teachers surveyed said that digital technologies were creating "an easily distracted generation with short attention spans." Teachers who were not involved in the surveys echoed their findings in interviews, saying they felt they had to work harder to capture and hold students' attention.

Similarly, of the 685 teachers surveyed in the Common Sense project, 71% said they thought technology was hurting attention span "somewhat" or "a lot." About 60% said it hindered students' ability to write and communicate face to face, and almost half said it hurt critical thinking and their ability to do homework.

Researchers who study the role of media in society say no long-term studies have been done that adequately show how and if student attention span has changed because of the use of digital technology. But there is mounting indirect evidence that constant use of technology can affect behavior, particularly in

developing brains, because of heavy stimulation and rapid shifts in attention.

On the other hand, surveys also found that many teachers said technology could be a useful educational tool. In the Pew survey, roughly 75% of teachers surveyed said that the Internet and search engines had a "mostly positive" impact on student research skills. They said such tools had made students more self-sufficient researchers. The Pew research found that 76% of teachers believed students had been conditioned by the Internet to find quick answers. This is a far cry from the hunt through a library card catalogue using the Dewey Decimal System.

Student confidence

Self-confidence is so important in achieving student success. This is equally true for males and females. Nationally, 20% of graduates with degrees in engineering are women, but only 11% of engineers are women. Some of this disparity can be attributed to self confidence.

Research at the University of Wisconsin-Milwaukee (UWM) indicates that the self-confidence instilled by parents and teachers is more important for young girls learning math and science than their initial interest. (Fouad, Smith and Hackett). This writer is of the opinion that a spark of interest must be rekindled and continuously reinforced to gain traction and have a lasting effect.

While interest is certainly a factor in getting older girls to study and pursue a career in these disciplines, more attention should be given to building confidence in their abilities early in their education, says UWM Distinguished Professor Nadya Fouad. She is one of the authors of a three-year study aimed at identifying supports and barriers that steer girls toward or away from science and math during their education..."The relationship between confidence and interest is close," says Fouad. "If they feel they can do it, it feeds their interest."

Many young students, particularly girls, see math and science as difficult, and don't take any more classes than they have to, not realizing they are cutting themselves off from lucrative opportunities in college and careers. Very often their peers discourage STEM pursuits, indicating that such academic tracks are for "nerds."

Overall, parent support and expectations emerged as the top support in both subjects and genders for middle and high school students. Engaging teachers and positive experiences with them help to support STEM. Although the study focused on females, the same can be said for males.

Mindsets and math/science achievement

Student mindsets set the baseline for achievement. If a student believes that he or she is "locked-in" to mathematics or science abilities by nature or some other reason to a fixed intellectual ability, with no room to improve, they are considered to have a "fixed mindset", with little chance for improvement and achievement. Those who believe they can develop skills and abilities have a "growth mindset". .There is a growing body of evidence that students' mindsets play a key role in their math and science achievement. (Dweck). Students who believe that intelligence or math and science ability is simply a fixed trait (a fixed mindset) are at a significant disadvantage compared to students who believe that their abilities can be developed (a growth mindset). Moreover, research is showing that these mindsets can play an important role in the relative underachievement of women and minorities in math and science. This is almost intuitive considering the level of reinforcement possible to do well. Research shows that a) mindsets can predict math/science achievement over time; b) mindsets can contribute to math/science achievement discrepancies for women and minorities; c) interventions that change mindsets can boost achievement and reduce achievement discrepancies; and d) educators play a key role in shaping students' mindsets.

The Florida STEM/M&S Workforce Model

The preceding treatment of the affective domain of our students sets the framework for the development of our students to become skilled, productive and responsible members of society. NCS, in conjunction with its government, industry and academic partners, developed a workforce model to serve as a common understanding of the elements necessary to plan for the future workforce. The model is shown in Figure 1. (The national picture is simply an extrapolation of what exists in Florida.) Years ago, the major employer in the M&S industry was military simulation companies as compared to the current wide spectrum of applications. Medical and entertainment uses are growing rapidly, particularly in Florida with its Medical City and the theme parks in the Orlando area. NCS has been focusing on the academic and industry certification infrastructure, feeding the industry and putting its limited resources where they will do the most good. This includes developing a curriculum for high schools, establishing an industry certification in M&S, arranging for internships and teacher training where possible. The latter is the "long pole in the tent" when implementing STEM education.

Figure 1 depicts the simulation industry pipeline that sustains and enables its growth. At one time as stated earlier, the industry was made up primarily by

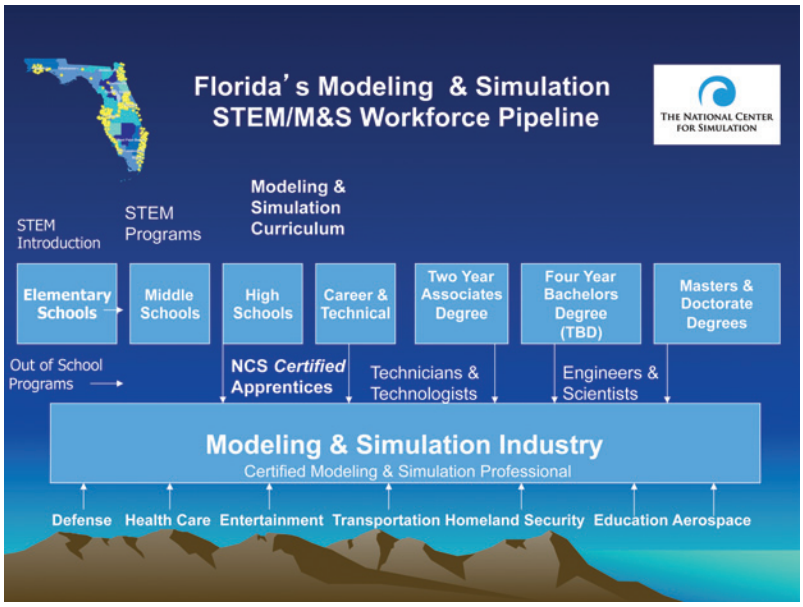

Figure 1: Florida M&S Workforce Pipeline

the defense component. Today, the applications of simulation technology have grown to include the areas shown. In all of the application areas there are test and evaluation requirements.

It all begins in elementary school where students can be exposed to simulation, become excited about its use and be made aware of exciting career possibilities. The simulation industry provides visits to company facilities to let the students experience simulated aircraft flights and other fun experiences using simulators. They learn how mathematics and science are applied to make the simulations work. NCS is also supporting the use of simulation programs in K-12.that help to explain concepts and give the students control by manipulating variables, etc. These programs are free or of low cost and available on the internet. A few examples are Kerbal Space Program, Physion, CK-12, PhET and the NASA Airfoil.

Florida is fortunate in having a university offer interdisciplinary graduate degrees in M&S, two year degrees in simulation and robotics and is contemplating offering a four year degree in M&S. At present, Old Dominion University is the only school offering that bachelors degree. Valencia College, previously a community college, is considering the four year bachelors degree.

It is also important to recognize that out-of-school instruction is very helpful in understanding and becoming involved in STEM. Visits to the science centers, museums, etc. can be fun and the children learn at the same time. Other organizations such as the Boy and Girl Scouts of America, YMCA and Boys and Girls Clubs have engaging STEM programs.

For the high school academic program, NCS and a large task force from industry, government and academia developed the four-year curriculum in modeling and simulation which will be described later. Along with the curriculum will be an industry certification in M&S that will be discussed also.

NCS member companies provide internship opportunities for students. This is very important. These internships will include flexible working arrangements to accommodate students' school schedules and take advantage of students' availability during school breaks. Through the NCS M&S Certification Program, the M&S industry is provided with a local pool of skilled and motivated students to fill paid and unpaid internship positions.

Students are eligible for these internship positions as rising sophomores, juniors, and seniors. All internship candidates must apply and be accepted into the NCS M&S Certification Program (i.e., have a minimum GPA of 3.0), must be enrolled in their school's M&S and/or STEM (science, technology, engineering, math) curriculum, and must have passed the certification exam or working towards taking it. Internship candidates who are deemed qualified based on their job application and transcript will be interviewed as part of the internship application and selection process.

M&S Curriculum

The "Florida" M&S curriculum was developed by a task force of industry, academia and government personnel, with members from the local school districts. The basis for the curriculum was a product developed by Old Dominion University. It was expanded to

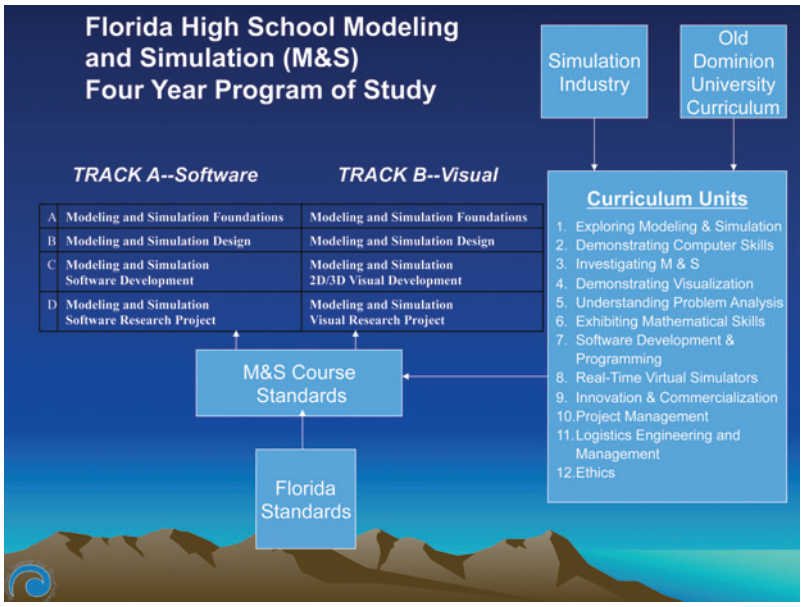

Figure 2: Florida High School M&S four year program of study

include more emphasis on virtual simulators and added project management, logistic support, entrepreneurship and innovation. The overall architecture is shown in Figure 2. The curriculum can be found, along with the proposed framework, on the NCS website: www.simulationinformation.com

The four year curriculum has two tracks: visualization and software development. The courses are identical the first two years and in the third year students take separate tracks. In the fourth year, the members of each track come together to work on a simulation project as a team. This represents the manner whereby interdisciplinary teams work in industry. Any school throughout the nation can take advantage of the curriculum in its entirety or adopt portions of it to fit their specific needs. There is no one school using the entire curriculum today. The strategy for development was to put forth all of the requirements of the simulation industry and the schools will evolve their programs to eventually have "magnet schools", employing the total set of instruction. At present, any teacher can pick and choose elements of the curriculum to meet their needs and use them to support approved instructional objectives. This "shopping cart" feature will provide a valuable resource for class activities and instruction not previously available. Over time, that "shopping cart" will continue to fill.

Figure 3: Student in the virtual world with author

Curriculum designers wanted to include as much hands-on instruction possible. The coursework includes exposure to various kinds of simulations including virtual reality. (Figure 3).

The most difficult issue to deal with has to do with teacher education. It is rare to find a teacher that has the experience and/or education to teach the entire program in M&S. Technology for the classroom as a subject is very limited in undergraduate teacher education. In many cases it only includes smart boards and power point presentations. The use of simulation as an instructional tool is rarely taught. Simulation is, however, finding its way into some undergraduate teacher education programs of study. In a few cases, simulation is being used to expose undergraduate teachers to a simulated class as shown in Figures 4 and 5. At the University of Central Florida, researchers have developed an avatar-based simulation of a classroom. The avatars replicate the behaviors a teacher might experience in the real world. Using this simulation, prospective teachers develop confidence and competence at the same time. This is a powerful tool.

University of Central Florida's teachLivE

Figure 4: University of Central Florida (UCF) teachLIVE simulated classroom

University of Central Florida's TeachLive

Figure 5: University of Central Florida (UCF) teachLIVE avatars

M&S Certification

The Florida Department of Education strongly recommended that NCS proceed with an industry certification, given that a four-year curriculum has been developed by the M&S industry as described earlier. This would open more doors for students seeking employment.

The underlying rationale for certification is to provide a qualified workforce able to support growing demands. The "supply" side for meeting these requirements is affected by: a) the number of people in the workforce who are retiring or eligible to retire within the next five years and b) the number of college graduates ready to enter the STEM workforce is at a new low.

An industry certification in M&S is in the process of being developed by an NCS industry group, led by Debra Yeagle, A-T Solutions. It is anticipated that high school juniors and seniors enrolled in M&S programs will want to be certified to gain internship and entry positions in the M&S industry. Certification will make the students more employable and productive as they enter the workforce on a part time basis as students and, in the long term, move up the career ladder with more education and experience.

NCS, in coordination with the Florida Departments of Education (FDOE) and Economic Opportunity (DEO), Career Source Florida, Inc. (CSFL), Career Source Central Florida (CSCFL), and Orange County and Seminole County Public Schools, is developing an industry certification program in M&S for high school (and other) students. This certification program is aligned with the NCS high school M&S curriculum, a four-year program preparing students for post-secondary education or entry level positions in industry or government. Students who complete this curriculum and those who have appropriate experience and/or other training may elect to take the NCS M&S Certification Exam.

Passing this exam and achieving certification demonstrates the student's proficiency in the fundamental skill set in M&S, thus providing the student with internship and scholarship opportunities, and facilitates the student to enter post-secondary education and/or to seek employment in industry or government. By enrolling in the NCS M&S Certification Program, taking advantage of internship opportunities, and successfully passing the certification exam, students are prepared for a rewarding, high paying career in a high tech industry. To be eligible for the M&S Certification Program, students must be enrolled in their school's M&S and/or STEM curriculum with a minimum GPA of 3.0.

By participating in the NCS M&S Certification Program, the school systems can obtain state funding and high-tech status to improve schools' overall grade. It also gives feedback for educators to assist with high school M&S curriculum program enhancement. Furthermore, teacher job satisfaction is increased and teachers are afforded summer employment opportunities through their valued M&S expertise.

This certification program benefits the M&S industry by creating student interest and a level of competency in science, technology, engineering, and mathematics disciplines, and preparing students for M&S careers in defense, medical, entertainment, business, education, training and other fields. The NCS M&S Certification Program provides the industry with a local pool of skilled and motivated students to fill paid and unpaid internship positions. High-performing interns provide experienced candidates for full time employment with retention benefits for industry. Additionally, students who are participants in the NCS M&S Certification Program are better prepared and are more qualified as candidates for full time employment in the M&S industry,

requiring less entry level training and improving overall productivity. Productivity and company competitiveness is also increased because the interns can assume low level STEM work that was formerly performed by entry level graduate engineers. Those engineers can now go on to do more creative and challenging tasks.

NCS is the industry accrediting body of this certification program and complies with the Florida Career and Professional Education (CAPE) Act, coordinating with the FDOE, DEO, CSFL, and CSCFL to ensure adherence to requirements and standards for academic frameworks and career and professional education.

Summary

M&S is an element of STEM that is used in many different applications to include defense, medical and health, homeland security, entertainment, transportation, education, etc. It is a big business and requires an educated and trained workforce. It is particularly significant in the state of Florida. Florida students, much like those throughout the nation, are faced with many challenges attributed to a changing technology, the digital revolution and their own abilities, attitudes, mindsets, parental involvement and encouragement by their support system members. NCS led a task force to develop an education and workforce model that includes a curriculum, framework of instruction and an industry certification in M&S. The model and curriculum are complete whereas the framework and certification are under development. Portions of the curriculum being used by teachers integral to their lesson plans. The Florida model can serve as a prototype for the rest of the nation. Following the NCS M&S "roadmap", it becomes a win-win for the simulation industry, the schools, parents and, most of all, the students.

HANK OKRASKI is a simulation consultant for the modeling and simulation industry. After 32 years of government service, he retired and is President/Chief Executive Officer of Henry C. Okraski and Associates in Winter Park, Florida.

While with the Navy and member of the Senior Executive Service, he was the Director of the Research and Engineering Department, Deputy Technical Director and Chief Scientist of the Naval Air Warfare Center training Systems Division. He served on NATO Study Groups and received several awards including the Navy Meritorious Service and Navy Superior Service Awards. Named Federal Engineer of the Year by the National Society of Professional Engineers. He is a founding member of the National Center for Simulation (NCS) and continues to serve on the Board of Directors. He is Chairman of the NCS Education and Workforce Development Committee. Mr. Okraski led a task force in developing a four-year high school curriculum in modeling and simulation. Mr. Okraski is a Registered Professional Engineer and Certified Modeling and Simulation Professional. Formerly, adjunct faculty member at Rollins College and University of Central Florida. He is the author of "The Wonderful World of Simulation."

Mr. Okraski has a bachelor's degree in electrical engineering from Clarkson University in Potsdam, NY and a master's degree in systems engineering from the University of Florida. He received, and is proud of, receiving the Golden Knight Award from Clarkson, the highest alumni award given by the university. He and his wife, Judy, live in Winter Park, Florida. They have six children and 14 grandchildren.

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