Journal of Ship Production, Vol. 25, No. 2, May 2009, pp. 59–68

Journal of
Ship Production

Reaching Out to the Future Generation of Shipbuilders and Shipbuilding Leaders

Christopher Skiba, Richard Boutwell, and **William Boze**

Northrop Grumman Shipbuilding—Newport News (NGSB-NN), Newport News, Virginia

The Office of Naval Research—recognizing the importance of education, specifically science and mathematics—embarked nearly a decade ago on their National Naval Responsibility for Naval Engineering program. Since then, academia, industry, and SNAME have increased their individual and collaborative efforts toward reaching out to students in an effort to share the excitement and opportunities available within the marine industry. Recently, in this vein, the Northrop Grumman Shipbuilding Apprentice School Chapter of the Hampton Roads SNAME chapter held a "Boat Design Competition," exposing more than 240 high school students from 10 school districts (30 teams from 18 different high schools) to the excitement and knowledge needed to prepare design, construction, and engineering packages using guidelines, lectures, and tutorial videos prepared by Apprentices and veteran naval architects. This was the first time high school students had the opportunity to compete in a head-to-head competition to design, construct, and operate the best boat relative to a number of prescribed requirements. The program also served to educate Apprentices in leadership, project management, research methods, brainstorming, naval architecture, and systems engineering as well as establish a nurturing relationship between student chapter and veteran SNAME members, which continues today.

Keyword: shipbuilding

1. Introduction: Motive behind the competition

The Bureau of Labor and Statistics, U.S. Department of Labor (BLS 2008) projects a need for nearly 11% growth in engineering jobs from 2006 to 2016. Contained within this prediction is growth of 11% of the need for marine engineers and naval architects because of

- A strong demand for naval and recreational vessels in the future
- Growth in employment as a result of the need to replace workers who retire or take other jobs
- Limited number of students pursuing careers in this occupation.

Yet, the United States ranks fourth (behind Russia, Israel, and Canada) in the population ages 25 to 64 with any postsecondary science or engineering degree (including 2-year and 4-year or higher degrees), and it ranks 10th (behind Russia, Canada, Japan, Israel, South Korea, Sweden, Belgium, Ireland, and Norway) in the population ages 25 to 34 with any postsecondary science or engineering degree (National Science Board 2008). Long gone are the days when the number of students entering engineering curriculums directly tracked the funding for the Apollo program or even the defense budget of the Reagan administration. Fortunately, the projected growth in engineering demand and the decline in students pursuing degrees leading to careers in the marine industry have prompted several organizations to take proactive steps.

The Office of Naval Research (ONR) recognized its national naval responsibility by looking at various scientific and naval fields, aligning academia, government, and industry to work together, and by funding relevant programs to ensure that the talent to design the Navy's next generation of ships and submarines will exist when needed. One of the student outreach programs initiated by ONR is the Massachusetts Institute of Technology (MIT) Sea Grant's Sea Perch program, which introduces precollege students

Manuscript received by JSP Committee from SPS 2008.

to the wonders of underwater robotics. The Sea Perch program challenges students to build an underwater self-propelled robot (called a Sea Perch), develop a controller, and investigate weight and buoyancy (Wallace 2008).

The Society of Naval Architecture and Marine Engineers (SNAME) has responded by assisting with the marketing of the Sea Perch Program, as well as by providing college students with career information, student chapters, mentoring programs, and scholarships. An examination of the society's website (www.sname.org) provides access to:

- An industry description
- Educational sources
- Employment opportunities
- Outreach videos
- Student chapter newsletters
- Mentoring programs
- Student member assistance in providing increased recognition of the importance of being part of a professional society
- Scholarships.

Such activities directly support one of the core missions of Society of Naval Architects and Marine Engineers, which is the: "furtherance of education in naval architecture, marine, and ocean engineering" (SNAME 1977).

In February 2008, shipbuilding companies along with government organizations and academic institutions joined together at Old Dominion University (ODU) in a Shipbuilding and Repair Career Day designed to educate middle and high school students on the products and services these industry representatives produce in addition to career opportunities (ODU 2008). This event was one of two held in the United States as part of the National Shipbuilding Research Program project; a project designed to inject "sizzle" into a marketing campaign for the industry. The ODU location consisted of an Expo requiring students to visit at least six industry booths and participate in hands-on activities designed by the Northrop Grumman Shipbuilding Apprentice School at Newport News in addition to touring BAE Systems Shipyard in Norfolk.

Also in 2008, 2 years from conception, the Northrop Grumman Shipbuilding Apprentice Student Chapter of SNAME responded further by holding its first annual High School Boat Design Competition. The Apprentice Student Chapter aligned with its parent chapter as well as Northrop Grumman Shipbuilding—Newport News (NGSB-NN), the Shipyard Apprentice School, local area high school districts, and Bass Pro Shops of Hampton, VA. By aligning interest, energy, and resources, the Apprentice Students successfully exposed high school students to the challenges and passion of ship design and construction in the interest of generating future shipbuilders and shipbuilding leaders (Fig. 1).

2. Northrop Grumman Shipbuilding Apprentice School SNAME Student Chapter

The Apprentice School chapter of SNAME was chartered in the spring of 2005 with the aspirations of strengthening the SNAME student chapter body and exploiting its uniqueness as a student section. Recognizing that Apprentice Students learn ship design and construction from classroom instruction supplemented by mentoring and hands-on application, the students wanted to use this successful formula along with their core values of craftsmanship, leadership, and scholarship to advance the student chapter membership strength by doing something meaningful for the society and industry.

The Apprentice Students were aware of the society's initiative of reaching out to grade school students and wanted to further that objective. Collectively, they asked, "What can we do that would promote the societies' values while utilizing our skills and talents

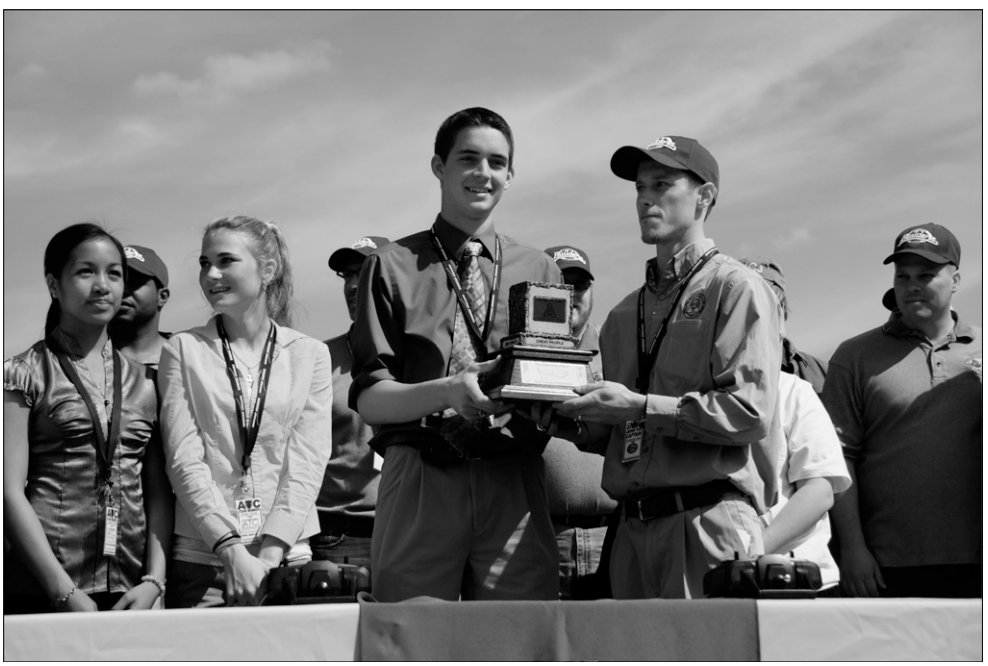

Fig. 1 Christopher Skiba (right) presents the first-ever SNAME Boat Design Contest trophy to Advanced Technology Center students from Virginia Beach, Virginia. Photo by Kathy McIntire

to expose precollege students to the excitement of the shipbuilding and marine industry?" This question was answered by the Student Chapter Advisor's vision of sponsoring a High School Boat Design Competition. After all, who better could relate to high school youth than Apprentice Students who are entering the profession? This vision would become the beginning of a long and rewarding journey beyond expectations, not only for the high school students, but for the Apprentice Students as well.

So with a unified vision, a team was formed and the apprentice students embarked on defining the competition and developing the guideline document. With the basis of the guidelines established, the Team Captain (Chris Skiba) and Student Chapter Faculty Advisor (Dr. Dick Boutwell) began marketing the idea to local school superintendents. To the team's surprise and pleasure, they captured the interest of 10 school districts throughout the Hampton Roads area, but quickly realized that this competition had now become a sizable undertaking requiring much time, effort, and devotion from each Apprentice Student from here on out. This concern was later heightened when 240 high school students registered for the competition. The focus then became how each Apprentice Student would manage attending school, their full-time job, tending to their families, and working this competition simultaneously? Fortunately, the answer presented itself when members of the parent local SNAME chapter joined the team in equal number, equipped with lots of experience and similar interest and passion. It was then that the Apprentice Student team realized it had the potential to transcend its original intent and redefine the chapter's uniqueness.

3. The high school student focus

The focus of the competition was to expose high school students to the excitement and passion of ship design and construction by teaching them ship design principles and processes while providing the opportunity for them to interact with apprentices and professionals within the industry. All this would have to be accomplished in a series of a few months (adhering to both a stringent competition and school schedule simultaneously) and without any prior exposure to basic naval architecture.

The approach would be to introduce the high school students to a microcosm of the entire shipbuilding process encapsulating:

- Concept definition
- Concept design
- Planning
- Detail design
- Construction
- Testing and validation.

Each student would combine this knowledge with a similar introduction to basic naval architectural principles towards designing and generating the products necessary for Apprentice Students to potentially construct their boat. They would later learn, through participation in the final lake event, how to validate and measure a boat's performance. This would make the event unique in that the students would learn basic systems engineering and naval architectural principles while being tutored by Apprentice Students and industry veterans. By interacting via e-mail and many planned face-to-face opportunities throughout the competition, the high school students would be exposed to the passion and energy of industry representatives and become aware of the potential opportunities that await them. This was best demonstrated during the interactive Orientation Session arranged by the Apprentice Team, where the high school students and all present were first captivated by a veteran naval architect demonstrating design exploration and out-of-the-box thinking. Once captivated, it was easy to continue further interaction with the students by engaging them in performing preliminary requirement and physical analyses and assisting them in understanding the interdependencies and potential conflicts when searching for a satisfying solution. In the end, the high school students came away energized and ready to begin exploring the design lanes in search for their winning solution.

Though the high school students were provided guidelines, an orientation session, and instructional videos, it was clear that they (just like the Apprentice Team) were going to have to learn other aspects such as project management and organizational behavior, as later became evident from their design history notebook submittals. The design history notebook is an informal journal that chronicles the highlights of each team meeting, concepts explored, difficulties encountered during the design process, and decisions that led to the final design. The notebooks provided the Apprentice Team insight into the high school student activities and approaches that highlighted the following:

- Time management was approached several different ways. Some established a set time during each day to meet or as time permitted. Some faculty members made the competition a part of their daily class work. This approach appeared to work the best based on gauged progress. Some schools dropped out because of schedule conflicts.
- Some schools explored the design space accepting the higher risk, while others resorted to what they knew would work by modeling their boat to known designs (rowboat-like).
- The high school teams had to deal with the discomfort of learning something foreign, such as the naval architecture formulas, which one student vividly portrayed as similar to "learning French."
- The project lead and the team had to learn how to manage stress and conflict.

The design history notebooks also revealed that competition was strong between schools and within school districts, and teams recognized that to advance they were going to have to provide a product superior to that of their competition. Though not fully recognizable from the design history notebooks received, the Apprentice Team realized that each team would begin to learn from the experience as they did some of the many effective approaches to collaborative team efforts, such as those outlined by Luthans (2008):

- Students were going to have to form right-sized teams, small enough to effectively tackle a task in a short period of time but large enough to provide a reasonable division of labor. Members should be selected based on motivation and competency.
- Project leads should be selected based on their ability to promote the creative juices of the team by effectively organizing their collaborative efforts.
- Group cohesiveness and strong leadership would yield high performance.
- Social loafing or reduced effort from team members would contribute to dysfunctional teams.

Plus for the two finalist teams, the Apprentice Team hoped each individual participant would get to experience the pride and

excitement of a successful effort. The benefit of this was later substantiated by John Hammons (York High School Technology Teacher and advisor to the York Falcons student team) in a quote from a local newspaper covering the final competition at the lake; "The experience was valuable…. It's very rare for kids to see something they design get built" (Grimes 2008).

In short, the desire of the Apprentice Team was for the high school students to experience something unlike they had ever encountered before, so that their view of educational and career opportunities would be broadened and the experience would have some intrinsic value.

4. The team became a learning organization

When the Apprentice Students embarked on the idea and vision of creating and holding a High School Boat Design Competition, their focus and attention were on educating the high school students. Little did they realize that this would be a learning opportunity for them too. This became clear when the Manager of Naval Architecture at Northrop Grumman Shipbuilding (Bill Boze) offered his assistance and announced at his first meeting that while the Apprentice Students would concentrate on the high school students, his mission would be to "use this opportunity to educate the Apprentice Students." Though Apprentice Students are educated in a variety of math and science courses in addition to ship construction methods and trade skills, the High School Boat Design Competition subjected the Apprentice Students to learning other skills and methods commonly used in managing multifaceted projects, lessons that are not contained within the Apprentice Schools formal course curriculum. These lessons can be easily grouped into three categories outside of Apprentice Students more comfortable knowledge of boat or ship construction: Engineering, Project Management, and Leadership.

4.1. Engineering

Learning naval architecture principles is required coursework for every Apprentice Student. Yet, as most everyone will agree, the best way to comprehend the theory is by practical application of that theory or teaching the theory to others. This High School Boat Design Competition provided the Apprentice Students the opportunity to learn by doing both. Determining what naval architectural principles were needed for the competition required the Apprentice Student team to examine the typical design process that they learned (for those who finished their naval architecture course), and the various formulas and methods for calculating weight, center of gravity, displacement, draft, trim, and stability. Wrestling with topics such as speed and maneuvering prediction took even more consideration, as these topics are more difficult to grasp and apply. In tackling the challenge of applying their own introductory knowledge toward the eventual instruction of high school students, the Apprentice Students prudently sought the assistance of naval architectural professionals within the parent SNAME society. By working with these professionals, the Apprentice Students began to better understand the approach and theory, in addition to learning and observing how the boat characteristics would be measured and validated. An example of validation that educated all Apprentice Student team members, high school students, parents, and other observers of the final competition was how the final high school boat weight was validated using a boat trailer, two scale measurements, a tape measure, and one longitudinal shift of the boat on the trailer. As explained to all during this portion of the boat competition validation, the derived formula from a naval architect support team member came from a simple application of the static equilibrium conditions (the sum of forces shall equal 0, and the sum of the moments about a common origin shall equal 0).

System validation during the project creation was also a lesson learned by the Apprentice Student Team members. For example, the radio-controlled propulsion and steering system was an integrated system designed by the Apprentice Team. When the system was built, the team took their outfitted prototype vessel to the lake for validation of the system and quickly learned the system had electrical and radio-control interference problems. By isolating portions of the system and performing bench tests with the assistance of Northrop Grumman Shipbuilding subject matter experts, the Apprentice Student team eventually solved the problems.

4.2. Project management

Perhaps the greatest lesson to the Apprentice Students during the development and execution of the High School Boat Design Competition was the effective project management methods and skills learned from the competition team parent chapter support group.

From the start of the project, the Apprentice Students quickly learned that balancing their own personal affairs, school, and this boat competition required that they learn effective time-management skills and that the additional burden of this competition would need to be equally shouldered by the Apprentice Student team members. However, as is typical with many volunteer activities, the actual contribution of time and energy was unequal, and students with the commitment to succeed had to either decide to take on additional tasks or make it clear to fellow team members that the team was counting on their successful execution of their assigned tasks.

To approach this project in a logical and effective fashion, the Apprentice Student team compartmentalized the competition into life-cycle phases that included:

- Phase I: The competition marketing and high school student registration process
- Phase II: The design rules and process
- Phase III: The construction, testing, and competition

This approach provided uniformity in project planning and control by:

- Allowing for benchmarking and brainstorming at each phase
- Allowing the team to have critical reviews of the plan
- Allowing the team to gain approval before proceeding to the next phase
- Capturing issues and risks to be resolved.

As the team walked through the planning of each phase, a bar chart schedule was constructed and adjusted based on team evaluation and feedback. Each section of the developed guidelines went through a systems-engineering-like requirements analysis, where team members challenged the wording and meaning of each sentence to ensure clarity of purpose and continuity of thought. As the team reviewed the guidelines, they also captured risks, without letting the tendency to "solve it now" get in the way

of making the progress planned for that day or week by deviating on a tangent. The documented risks would later be reviewed and mitigated accordingly, until the residual risk was reduced to acceptable levels. These risks also included identification of potential injury to high school students, Apprentice Students, SNAME members, and observers of the final competition day. The Apprentice Students learned that even the lawyers and city needed to weigh in on the plan.

One particular challenge in developing the guidelines was the configuration management of the vision and guideline document itself throughout its development. Initially, sections of the guidelines were parsed out to subcommittees to develop and mature. However, along the way, especially in the beginning, the individual section contents began to diverge or conflict, and even the identification of the latest document version became difficult. So the Apprentice Students had to reestablish a Guideline Document baseline so they could begin exercising a change control process, in which the changes were passed through a document lead and team captain.

The need for effective communication also became apparent to the team relatively early in the competition planning. The team used regular team e-mail distributions, a dedicated computer network drive folder for posting the latest documents, meeting minutes with assigned actions and action parties, and regular phone calls between the team captain, subcommittee team leads, and team advisors. Recognizing the importance of communication, the team established a communication plan within the competition guidelines and a website for the high school students to access registration information, announcements, training and orientation videos, and answers to frequently asked questions (FAQs).

Interfacing collaboratively with other entities was best exemplified by the team's desire to use Bass Pro Shops in Hampton, VA, for launching and operating the two finalist boats at the lake adjacent to their facility. The Apprentice Team had to meet with the Marketing Director and sell their idea in the hopes of generating enough interest for the store to take part in executing the lake competition. Fortunately, the Bass Pro Shops reception was beyond expectations, and the team quickly began formulating interface documents that captured:

- The division of responsibility for material, labor support, marketing, and any necessary approvals/permits
- The lake course layout
- The public viewing area
- The parking lot layout for performing weight and center of gravity validation
- The schedule (competition was held concurrent with the store's popular Spring Fishing Classic).

Working with the Bass Pro Shops provided an excellent opportunity for the Apprentice Team to learn effective interfacing techniques.

The Apprentice Students also learned that for any project involving a sponsor, they must continually maintain communication during the planning and execution. Aside from the obvious sponsor interest in cost, schedule, and in this case high school student interest, the Apprentice Students quickly learned that executive sponsors would have other unanticipated demands, such as repainting the Apprentice Student prototype boat in the school colors just prior to the Finalist Luncheon. This resulted in the student team manhandling a freshly painted but sticky hull through a corporate office building lobby, narrow elevator, and general meeting space to put the vessel on display. Needless to say, all the boat handlers walked away with paint on their hands and clothing to be worn at the luncheon. Another example was resolving the conflict that materialized when a vice president of Northrop Grumman Shipbuilding (a key sponsor) requested the boat competition at the lake be held later in the day so he could arrive from Washington, D.C. and be present for the competition. Unfortunately, the schedule was already sent and widely broadcasted to schools and school superintendents, mayor's offices, Bass Pro Shops, and the media. Fortunately, this vice president understood placing people ahead of himself and allowed the competition to proceed as originally planned.

4.3. Leadership

Harold Kerzner (2006) captures the intended lesson that the two student chapter advisors wanted most to teach the Apprentice Team members. In his list of dos and don'ts, Kerzner identifies understanding the expectations as one of four variables for gauging a team's success. According to Kerzner, and as learned by the Boat Design Competition Team Captain, the project team expects the project leader to:

- Assist in the problem-solving process by coming up with ideas
- Provide proper direction and leadership
- Provide a relaxed environment
- Interact informally with all the team members
- Stimulate the group process
- Facilitate adoption of new members
- Reduce conflicts
- Defend the team against outside pressure
- Resist change
- Act as a group spokesperson
- Provide representation with higher management.

Likewise, the project team members learned the expectations of the Boat Design Competition Team Captain and advisors, which included (Kerzner 2006):

- Commitment to the project
- A can-do attitude; results oriented
- Resourceful with the capacity to resolve problems
- Clear and constant communication
- Creative thinking and innovation
- Respect to all members
- An environment that bolstered morale and participation.

These behaviors were initially exemplified by the veteran team members as seen through the eyes of Chris Skiba, the Boat Design Competition Team Captain. "They (the veteran team members) were committed to supporting the Apprentice Team members" noted Chris, "and they did so voluntarily with positive attitude, energy, respect, and a willingness to bestow knowledge without expecting anything in return." Thus, it was easy to understand why, early on in the project, the behaviors of the veteran team were matched by the Apprentice Team members. This was but one of the many examples of effective leadership demonstrated and conveyed to the Apprentice Student Team members.

Another leadership lesson learned by the Apprentice Team members was in mentoring. From the beginning, the behavior of

the veteran team members demonstrated that leaders treat followers more as partners than underlings. This was initially a foreign concept for the Apprentice Students since the veteran team consisted of several PhDs, managers, supervisors, senior designers, and naval architects. The Apprentice Students' tendency to "speak only when spoken to" when in the presence of more senior personnel was eventually replaced by a partnership-driven mentorship of equality and trust.

Even more noteworthy was the veteran team's inclination to let the Apprentice Students learn by struggling and finding their own way, though admittedly there were occasions when this intent was trumped unintentionally by an overly enthusiastic veteran team response. Even so, self-reflection of the veteran team's response also demonstrated to the Apprentice Student team the need to evaluate and correct behavior along the way.

Perhaps again the view of the Boat Design Competition Team Captain, Christopher Skiba, best captures the perspective of this learning experience:

> *As young professionals in the industry, it is hard to comprehend the value of mentorship. It is a term that is usually thrown around but rarely is its true meaning unraveled. Life is a collection of one's experiences, some bad and some good. These experiences make us who we are. It is usually realized later in one's career, looking back and realizing those individuals who made a difference in their life. Having the opportunity to comprehend the meaning early in life can have a positive impact on a young person's career. Mentors possess wisdom and experience that can serve as examples to young individuals who are willing to learn and absorb this knowledge. This competition serves as an example of effective mentoring and the positive influence it can have to both the mentor and mentee. For me, this nurturing relationship which continues today has been invaluable. I hope other young professions will benefit likewise by other senior professionals taking advantage of any opportunity to mentor others.*

5. Competition details

5.1. The Apprentice Team approach to writing the guidelines

The Apprentice Team, supported by NGSB-NN naval architects, developed an extensive set of competition instructions along with detailed guidelines and requirements typically used by ship designers (see http://www.apprenticeschool.com/sname_competition.html). The guidelines were prepared collaboratively by the team over the course of about 2 months. From benchmarking of similar initiatives researched, the team was able to quickly envision the scope and content of the guidelines that would be suitable for this competition.

An outline was generated, and the team brainstormed the potential approaches, required section contents, issues and risks, and possible solutions. The team used this approach and its ensuing meeting minutes to ensure no detail was overlooked. In the course of these sessions, the Apprentice Students were quick to observe the effective methods for managing team brainstorming sessions, the importance of not allowing more vocal members to be overbearing, the need to clearly identify guideline section leads and group assignments with periodic follow-up on those assignments, and configuration management of the Guideline document to reflect changes as they occurred.

Upon completion of the requirements, risks, and validation analyses of the guidelines, the Apprentice Students embarked on designing and building a boat themselves in order to validate the guidelines, the propulsion and steering systems interface requirements, and the radio-control system. In addition to building the craft, the Apprentice Students also had to select and purchase a set of propulsion trolling motors, propulsion batteries, and radio-control transmitters and receivers. The Apprentice Student effort included the design, fabrication, assembly, and testing of the power supply wiring harness, radio-controlled power on/off switch, and radio-controlled steering-control system (made up of separate power supply, servo, and rudder arm linkages). It turned out that this latter effort became the critical path for the entire boat competition as a result of radiofrequency range and interference issues experienced on the lake. This demonstrated the importance of validation, scheduling, and professional networking (knowing where to find subject matter experts quickly for assistance in troubleshooting systems).

5.2. Competition guidelines and website contents

The competition required high school students to work independently to design the fastest and most maneuverable boat capable of transporting 200 pounds of bulk sand. The boat could require no more than three sheets of 10 ft by 5 ft, 1/8 in. thick steel plates and had to interface properly with the standard propulsion motor, propulsion battery, power cable, and steering assembly provided by the Apprentice Students.

High school students were required to furnish supporting naval architectural calculations for basic hull hydrostatics, as well as a weight report and intact stability analysis. In addition to the calculation package, the students were also required to provide a design and construction package including:

- A Design History Notebook capturing design discussions, decisions, meeting minutes, issues, and risks
- Design drawings including plan, elevation, section, and isometric views of the boat design
- Construction drawings providing the views, details, dimensioning, material list, part numbers, and notes necessary to construct the boat
- A two-dimensional (2D) nesting plan showing the scaled layout of each piece on the steel plate to ensure that the required pieces can be fabricated from the material provided
- A paint drawing to identify the colors (limited to two) and pattern scheme (limited to three zones)
- A loading diagram identifying the location of the receptacles for carrying the bulk sand.

Two designs from the high school team submissions were selected by the Apprentice Students based on judging criteria and constructed by Apprentice Students for an eventual head-to-head competition at a lake. The design judging was accomplished by the naval architecture support team and Apprentice Students using weighted judging criteria that included:

- Format and content of the Design History Notebook
- Clarity of the design

- Proper detail drawing views
- Correct drawing dimensioning
- Completeness and correctness of the calculation package
- Creativity.

The winner of the head-to-head competition was based on the clarity of the construction drawings, accuracy of the calculations for weight, center of gravity, draft, trim, and stability (through measured validation), as well as lowest timed speed, measured boat turning radius, and observed team engagement. The competition was held at a lake belonging to the City of Hampton and was marketed and supported with assistance from Bass Pro Shops of Hampton.

High school students became familiar with the basic shipbuilding principles and skill sets through an appendix to the guidelines containing an overview of the boat design process, naval architecture formulas and performance metrics, basic computer-aided design (CAD) drawing format and content, and stability measurements. To assist the high school students with their comprehension of the contents of the appendix, the Apprentice Students planned and held an Orientation Session at the Virginia Advanced Shipbuilding Carrier Integration Center (VASCIC) at NGSB-NN. High school students who attended were provided open remarks from their primary corporate sponsors, Mr. Danny Hunley, VP of Operations at Northrop Grumman Shipbuilding, and Bob Leber, Director of Workforce Development. Following the opening remarks, the high school students were provided a competition overview by the Design Competition Coordinator and a Design Approach Overview from the Manager of Naval Architecture at Northrop Grumman Shipbuilding.

Because of the anticipated risk and concern of high school students not being able to grasp the required naval architectural computations for this competition, the Apprentice team produced video tutorials in the subject areas of calculating weight and center of gravity, displacement, longitudinal and vertical center of buoyancy, longitudinal center of flotation, trim, and stability and qualifying speed and maneuvering characteristics. Both the Orientation video (for those unable to attend) and calculation tutorial videos were posted on the Apprentice Student competition website. The site proved particularly beneficial since the high school student teams all reported that they revisited the videos periodically to assist with their understanding of the principles of ship design. A Frequently Asked Questions (FAQs) site was posted on the competition website and was updated as high school teams submitted questions. (For Orientation videos, tutorial videos, and FAQs, see http://www.apprenticeschool.com/sname_competition.html.) Additionally, a preliminary design package submittal was encouraged so that the Apprentice Students and support naval architecture team could coach the high school students through the calculations and any observed deficiencies that would potentially result in an inadequate design.

6. Competition day

Once all the teams' final submittals were accepted and judged, the Apprentice Students with NGSB-NN sponsors hosted an appreciation luncheon for the participants. The main purpose of the luncheon was to announce the two winning finalist teams. At this luncheon, the high school students also got the opportunity to view the outfitted Apprentice Student prototype boat, as well as each high school team's design submittal, which were displayed throughout the room. Though the selection process was rigorous, the judges finally came to agreement; with the winning designs coming from The Falcons of York High School and the "Sink Oar Swim" team from the Advanced Technology Center (ATC) in Virginia Beach. The design from "Sink Oar Swim" used a catamaran hull concept to enhance the boat's stability and maneuverability. On the other hand, the York Falcons design used a more traditional and sleek hull shape to try to gain the advantage with speed.

With the top two designs chosen, construction of the boats began in the shipyard's steel fabrication Apprentice Gallery. Using the actual plans drawn by the winning teams, the boats were constructed by Apprentice Students who are learning the art of shipbuilding and gaining hands-on experience at the same time. The build process moved along swiftly and soon both boats were completed and ready to be tested for seaworthiness.

The Apprentice School SNAME team took the boats to the Bass Pro Shops Lake in Hampton, VA, to outfit them for remote-control steering and to check the boat and systems performance. Next, the Falcons and "Sink Oar Swim" teams came to the race site (on different days) to get familiar with the course and how the boats responded to the controls. Finally, on a cold, clear Saturday morning of March 15, race day arrived! The crowds gathered in front of the Bass Pro Shops and admired the two finalist teams' boats and the Apprentice prototype on display.

Once the judges validated the weight and center of gravity of each boat (Fig. 2), each team chose a member to officially christen their vessel, an ancient shipbuilding tradition (Fig. 3). In appreciation of their support, a representative from the Bass Pro Shops was given the honor of christening the Apprentice prototype vessel.

Next, the crowd moved to the racing platform as the two competing boats were outfitted with their propulsion, steering system, and payload (200 pounds of sand) at the launch site (Fig. 4 and 5). With encouraging words from the Mayor of Hampton, the competition was finally ready to get underway and, after a quick sallying test to verify stability, the competitors were given the remote controls.

Each team passed through the course on three timed speed runs (Fig. 6), and an average score of the three passes was compiled.

Fig. 2 Final competition validation of boat weight and center of gravity

Fig. 3 Christening of "Sink Oar Swim," Advanced Technology Center

Fig. 5 Participants and spectators watch the approach of the boats to the course

The competition was close with the sleek design of the York Falcons vessel giving it an advantage in the speed category. The judges worked together at the launch site and at the podium to keep the crowd informed throughout the scoring process.

After both teams completed their speed passes, they were next judged on maneuverability by comparing the turning radius of each vessel. The catamaran style design chosen by the ATC "Sink Oar Swim" team produced a small turning radius and gave the ATC the clear lead in the maneuverability category. After the three runs were made for maneuverability, final tallies were calculated for all categories.

Before awarding the First Annual SNAME Apprentice School High School Boat Design Competition trophy to the first place winner, special recognition awards were also presented to participants who excelled in other aspects of the competition. The Best Design Notebook resulted in a tie, with an award going to "Sink Oar Swim" from ATC and Woodrow Wilson's "Team Toad." The Best Overall Drawing Package went to York High. The Best Construction Drawing went to "Chicken of the Sea" from ATC. Most Creative Approach went to Landstown High, and the "Chicken of the Sea" team from ATC won the Closest to Vessel Performance Requirements award. However, when all categories were finally tallied, it was the Advance Technology Center Team from Virginia Beach and their "Sink Oar Swim" catamaran boat that took top honors. Although slower than the York's Falcon vessel, the little red boat's nimble maneuverability put it over the top to become the first winner of what is hoped will become an annual tradition.

7. Maritime industry strategic challenges

The Maritime industry faces many workforce-related challenges that threaten its future vitality. Workforce challenges include the skill drain resulting from higher rates of retirees, recruitment of young people into an industry with low perceived glamour, high technical skill requirements due to the advanced shipbuilding/operational characteristics, organizational complexity associated with long and interactive value streams, retention of skilled employees, and, finally, higher levels of accountability for cost and schedule efficiency issues.

The NGSB Apprentice School SNAME Chapter Boat Design Competition was an unqualified success. However, that success is

Fig. 4 Boats outfitted and loaded awaiting signal to get underway

Fig. 6 Both high school entries making a pass by the crowd

not merely measured by two high school design boats, built by Apprentice students, going head-to-head on a local lake. This competition is a microcosm for reducing the workforce challenges facing the maritime industry. The issues facing the industry are the same issues faced during the planning and executing of this competition. Those issues were:

- Recruiting students into a complex and interactive value stream: competition design planning and execution
- Transferring knowledge from mature naval architects to inexperienced apprentice students for planning and execution
- Changing the high-touch low-tech personal and functional experience of apprentices to low-touch high-tech shipbuilding perspective
- Changing the industry image associated with ship design and building from low esteem to a high value, challenging, and exciting image
- Engendering the belief that high cognitive requirements can be successfully met by average hard-working students
- Retaining highly skilled employees
- Developing metrics that really count with initiatives that really matter to employees.

8. Mitigating these challenges

Human behavior is based on personal values and attitudes. Attitudes are formed based on experiences. Behaviors generate results, which are tested against one's values. As results and behavior continue to be aligned and reinforced, permanent behavior and attitude change is highly probable.

For NGSB-NN and SNAME, the strategy executed in the boat competition included:

- Expanding apprentice students and naval architects from their operational to tactical and strategic perspective: Why do this? What does it mean to me? What are our professional and personal obligations to SNAME?
- Students experiencing the value stream, resolving inadequate solutions, learning that their contributions really make a difference and that with challenges, come opportunities.
- Using experts with special knowledge and skills to nurture young employees/students. The competition developed a highly successful informal mentoring element based on problem-based situations. These situations became the vehicle to jointly solve design and build problems. Bonds were formed that engender new competencies and professional attitudes.
- Apprentices seeing more than part-task activities or at times isolated chaos. It is only time and experience that expands this perspective into whole task challenges and opportunities.
- Teaching dedication and commitment. Once apprentice students and naval architects joined the competition team they never left voluntarily. The project lasted 2 years from concept to execution, and the members remained because they understood the value of their contribution, they were growing intellectually (becoming more competent), and they were part of a group of people who shared their values.

As a result of this strategy, the Apprentice School SNAME Chapter students and parent SNAME chapter members who participated in this endeavor experienced a positive change in behavior and attitude, with enthusiasm to contribute more to the industry, their respective organizations, and the Society.

9. Opportunities of the future

This year's success has inevitably paved the way for next year's journey. Based on the welcoming response from the high schools, local community, Northrop Grumman Shipbuilding, SNAME, and the Competition Design Team toward the first annual competition, it is the student chapter's vision to eventually expand the competition to all high schools on a national level. This will require a tremendous amount of support outside of the current contributors. One objective going forward is to have additional support from other SNAME student chapters, allowing this competition to be a shared initiative that can bring all the chapters together for a common good.

Currently, the chapter has begun the work preparing for the second year competition, which will be opened to all high schools in the state of Virginia. This progression will allow the program to be tested on a larger scale and will provide for an assessment of the added workload and resources required for future competitions at a national level. Team member sessions have been held with documented lessons learned from the first competition being applied to the next competition. Everyone is looking forward to the challenges ahead and another fruitful year of events.

10. Conclusions

This boat design competition exceeded all expectations, from the significant high school and community response, to the nurturing and mentoring of apprentice students by industry veterans that continues today. From vision, leadership, collaboration, sense of purpose, and opportunity came an experience that all who participated or attended will remember.

The desire of the Apprentice Team was for the high school students to experience something unlike they had ever encountered before, so that their view of educational and career opportunities would be broadened and that the experience would have some intrinsic value (Fig. 7). Perhaps the best overall summary of the Apprentice Teams success comes from Dr. Patrick Konopnicki (Director of Technical and Career Education, Virginia Beach City Public Schools Advanced Technology Center), whose team took the grand prize:

The SNAME project was an excellent example of project based learning that had many STEM (science, technology, engineering and mathematics) related aspects which helped ATC students realize CAD principles within the marine design/build real world context. The fact that students were engaged in not only product design but also able to view its completion and then perform test operations was a phenomenal learning experience. Visiting Virginia Beach City Public School administrators were quite impressed with the STEM math engineering concepts involved in the SNAME project.

The ATC students were impressed with the professional attention and detail found in the design feedback and eventual prototype construction. Newfound passion and excitement for the marine industry could be seen in fellow ATC students. This

Fig. 7 The Apprentice Student SNAME Chapter High School Boat Competition Team (from left to right): standing—Dr. Robert Leber (Director, Workforce Development), Carlyn Swanson, Neil Rosenbaum, Todd Corr, Renard McFarland, Vernon Hall, Jr., Kristin Podruchny (Student Chapter Chair), William Boze (Technical Leader), Dr. Richard Boutwell (Student Advisor), Nathaniel Pauley; kneeling—Spencer Moyer, Christopher Skiba (Boat Design Competition Team Captain), and Alan Anderson. Photo by Kathy McIntire

Fig. 8 SNAME Naval Architecture Support Team members (from left to right): Alan Titcomb (NGSB), Dean Royal (NGSB), Melissa Cooley (NGSB), and Elizabeth Heaney (NGSB). Photo by Scott Patten (NGSB)

is further evidenced by the fact that we have full enrollment in our upcoming Marine Design Engineering course that will be offered for the first time at the ATC in the fall of 2008.

Career and Technical Education educators have known for quite some time the benefits of experiential, hands-on learning. The SNAME project both enriched and extended the CAD curriculum well beyond what we thought at the ATC would be possible.

To the authors, it is clear that the industry's marketing campaign is beginning to make a difference. More and more government, industry, and academic collaboration efforts are arising and the "sizzle" in the campaign is beginning to leave its mark. But we must not stop with the current level of outreach. You too can help attract and invest in the next generation of ship designers, builders, and marine industry leaders by becoming active in any one of the many student outreach programs (Fig. 8).

Acknowledgments

The authors and the team would like to thank Northrop Grumman Shipbuilding—Newport News and Bass Pro Shops of Hampton, VA, for their sponsorship and acknowledge the individual contributions of the following team members (in alphabetical order) whose help made this a successful project: Drake Akroyd, Walt Altice, Rae Balson, Burton Benson, James Broncheau, Danny Brookman, Melissa Cooley, Jennifer Dellapenta, Pete Diakun, Sekou Frye, Mike Gravitt, David Hansch, Elizabeth Heaney, Jessicah Hegeman, Roger Herndon, Sandra Horton (Marketing-Bass Pro Shops Hampton), Danny Hunley (NGSB-NN VP Operations), Joe Jinnette, Lee Lambertson, Dr. Robert P. Leber (NGSB-NN Director, Workforce Development), Kathy McIntire, Maury Middleton, Gaylon Montgomery, Kelly Munns, David Powell, Dean Royal, Michael Rugnetta, Jennifer Ryan, Patrick Ryan, Alan Titcomb, John Wander, and Harold Weissler.

References

BLS. 2008 *Occupational Outlook Handbook,* 2008–09 ed., Bulletin 2700, Bureau of Labor and Statistics, U.S. Department of Labor Superintendent of Documents, U.S. Government Printing Office, Washington, DC.

GRIMES, C. 2008 Students put creativity, math skills to watery test, *Daily Press,* Newport News, VA, March 16, 2008, A4.

KERZNER, H. 2006 *Project Management—A Systems Approach to Planning, Scheduling and Controlling,* 9th ed., John Wiley & Sons, Hoboken, NJ, 360.

LUTHANS, F. 2008 *Organizational Behavior,* 11th ed., McGraw-Hill Irvin, New York.

National Science Board. 2008 *Science and Engineering Indicators 2008,* Vol. 1, NSB 08-01, 2–37, National Science Foundation, Arlington, VA.

ODU. 2008 *Shipbuilding and Repair Career Day a Success,* Old Dominion University News Archive for Norfolk, VA, February.

SNAME. 1977 *Society Bylaws,* The Society of Naval Architects and Marine Engineers, Jersey City, NJ, 5.

WALLACE, S. 2008 ASNE Delaware Valley Chapter teaches students naval engineering through the Sea Perch Underwater Robotics Program, *Naval Engineers Journal, American Society of Naval Engineers,* **1,** 23–27.