Int. J. Engng Ed. Vol. 18, No. 1, pp. 98–105, 2002
Printed in Great Britain.
0949-149X/91 $3.00+0.00

Introduction of Software Packages in Naval Architecture, Marine and Ocean Engineering Courses*

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Graduates from UNOs Naval Architecture and Marine Engineering NAME program enter professional employment with both commercial companies and government agencies. A series of meetings with their employers has lead to a shift in what is needed by engineering graduates in the area of computer capability. This paper discusses the industry input, how we are meeting this challenge, the student perceptions and the evolution of the UNO-NAME software introduction.

INTRODUCTION TO TRENDS IN COMPUTER UTILIZATION

THERE IS A close relationship between the University of New Orleans, (UNO) School of Naval Architecture and Marine Engineering (NAME) and the marine industry. The UNO-NAME program was started in order to provide naval architects and marine engineers for Louisiana's marine design firms and shipyards in the Gulf of Mexico. When the UNO-NAME program began in the 1980s, the curriculum was focused on developing the student's skills in programming design calculations such as ship hydrostatics and midship section structure. This focus began to shift around 1987–90 to performing these calculations on spreadsheets.

In the past decade (1990–2000), a number of naval architecture and marine engineering software packages have appeared. These packages have been developed to a user-friendly level, which makes them attractive for both commercial applications and university courses. In this context, the theory, numerical algorithm is first introduced. In some cases it is assigned as a homework, then the computer software package is introduced to the class.

Industry requirements for computer usage

Over the past decade, there have been several studies on redirecting engineering education towards meeting the industrial needs of industry [1]. A similar need has emerged in the marine industry. This is reflected in the engineering criteria 2000 for accreditation [2]. Input from marine design firms and shipyards identified the need for naval architects and marine engineers who productively utilize naval architecture and structural analysis design packages. These include CAD, hydrostatics, hull fairing, CFD of hull fairing, CFD of hull flow, as well as structural design using classification society software and finite element analysis (FEA). Users of these software packages can point to a number of situations where they are unable to be used. This has resulted in a user-programmer dialogue and there is optimism that these limits will be removed in newer releases. In the meantime, the industry relies on recent naval architecture and marine engineer graduates to resolve these software problems.

Overview of uno-name ship and offshore structure design courses

It is useful to briefly summarize the ship and offshore structure design courses. They are organized to provide a continual exposure of the student to design problems and their solution [3]. UNO-NAME student design experience begins in NAME 2150/2160 with an overview of ship and offshore structure design and related in naval architecture. The students study the classical naval architecture topics of hydrostatics, stability, and lines plan development typically with spreadsheets and manual drawings.

The design experience is then expanded in the junior (3rd year) and senior (4th year) courses. Ship/offshore structural design and analysis are taught in NAME 3120. The NAME 3120 project is the design of a ship's midship section following the American Bureau of Shipping (ABS) classification requirements. Machinery selection and

* Accepted 10 September 2001.

Table 1. Computer usage in UNO-NAME courses 1995–96 [3]

Course	Computer Programs	Computer Project
NAME 3140	Hull curvature, pump-pipe matching	SHCP hydrostatics
NAME 3150	Wave pattern calculation, propeller chart calculation	EHP data analysis lab
NAME 3160		Vibration project
NAME 4131	Optimization calculation	Dynamic programming
NAME 4150	Various design ex.	Design project
NAME 4151	Design calculation.	Database development project
NAME 4155	Design cal.	Design project cal.
NAME 4162	Design cal.	Run ship motions program

propeller matching (determining the engine/propeller operating point and vessel speed) are taught in NAME 3130. Computer-aided design software is used for exercises in NAME 3140. The fundamentals of ship resistance and propulsion are taught in NAME 3150. In NAME 3150 ship propulsion and propeller design problems are solved by systematic series and model test data. The fundamentals of ship vibration theory are described in NAME 3160 for solving problems of ship hull/accommodation vibration, random forcing, hull vibration and ship motions.

The capstone design course sequence NAME 4150/4155 is taught over two semesters. NAME 4160 is concerned with general requirements of principal dimensions, hull form, powering, stability, outfit, and structural design. In NAME 4155, the design project is refined and modified by the students following the instructor's suggestions as well as satisfying regulatory and safety codes. Recently, the NAME 4150–4155 senior design project has been done with software packages. The course grade is based on the report as well as the delivery of an oral presentation. UNO-NAME junior and senior level students have presented their student design at the Gulf Section of SNAME.

Each student will also complete design electives. These are selected from the following courses:

NAME 4120—Advanced Structural Design Analysis
NAME 4130—Advanced Marine Machinery
NAME 4151—High-speed Craft
NAME 4160—Advanced Hydrodynamics
NAME 4162—Ship Motions

FOCUS OF COMPUTER EXPERIENCE

The emphasis on developing NAME graduates with competence in the engineering application of computers and software to naval architecture and marine engineering is an important aspect of the UNO-NAME program. This is further reinforced as UNO-NAME students work part time in the local marine industry [3]. In the freshmen year, a NAME major completes CSCI 1201 (FORTRAN Programming) along with ENME 1781 (Computer-Aided Engineering Graphics). These courses are organized to develop the student's ability to write programs and use CAD and other software. The NAME faculty has adopted a policy of including at least one computer exercise in each NAME course. Table 1 summarizes computer use in the UNO-NAME course sequence in the transitional period 1995–96 when NAME 4150/4155 was reorganized. This represented the initial step in the current development of the NAME Computer Labs.

Computer lab development

Some colleges and universities have adopted a policy of recommending PC systems and in some cases supplying them to entering students. In

Table 2. Seven rules for computer use in UNO Naval Architecture and Marine Engineering Computer Laboratory Room 209 Engineering

No.	Rule
1	**Keep your area clean.** Don't make your fellow students, professors, or staff have to clean up after you.
2	**Do not store your files on the local hard drive.** Use floppies (make duplicates) to store your files.
3	**Do not install any software on these computers.** There are two reasons for this. First, programs installed on Windows 95 often make changes to the way the computer is configured. The installation of a piece of software may make the computer unstable and prone to crashes. Second, the software police have been performing unannounced audits here at UNO. The rules are very strict, even a legal copy without the proper documentation on hand is considered illegal.
4	**Keep printer use reasonable.** Toner and ink cartridges are very expensive. Avoid using the default gray background for graphs etc. Use color printer when only color will do.
5	**Follow this priority of access.** Please do not abuse your priority status to use the computers for other than the time needed and the intended use. **1. NAME 4150/55 students working on Senior Design** **2. NAME 3140 students working on class assignments** **3. NAME students working on other NAME class work (including graduate work)** **4. NAME students working on non-NAME class work**
6	**Please allow students with higher priority to take your seat without question!**
7	**Report hardware and software problems to the instructor or e-mail to Mr. Morrissey.**

Table 3. UNO-NAME design software inventory 1998–1999

Design Activity	Software Package	Copy Number	Acquisition/Notes
I. Lines Fairing	AutoShip	1	
	Nautilus	3	
	AeroHydro	1	Network License
	FastShip	5	
II. Stability-Hydrostatics	AutoHydro	1	Incl. In AutoShip
	Nautilus	1	
	GHS	4	Hardware Lock
	HEC	4	Hardware Lock
III. Resistance-Propulsion	Auto Power	1	Incl. in AutoShip
	NavCad	5	Network License
IV. Structural Design	AutoBuild	1	Hardware Locks
	ABS Safe Hull	4	Incl. in ABS Safe Hull
	MAESTRO		Incl. in ABS Safe Hull
V. Finite Element Analysis	FEMAP	—	Incl. in AutoShip
	GIFTS	—	Incl. in ABS Safe Hull
	ALGOR	—	Site
	StruCAD	5	Network License
VI. High Speed Craft Design	ABS Rules	3	Spreadsheet
	Lloyds Rules	1	Spreadsheet
	DNV Rules	1	Spreadsheet

contrast, UNO colleges and departments maintain computer laboratories. The UNO-NAME houses its computers in the Ship Design Labs (Room 209 in the engineering building). The rules for using this room are summarized in Table 2.

The computer systems in the Ship Design Lab (Room 209) are used primarily in support of the Senior Ship Design sequence (NAME 4150/4155) and the Computers in Naval Architecture (NAME 3140) course.

There are currently six computers in the Ship Design Lab. Four are 300/350 MHz Pentium II machines, with 96 mb RAM, 10 gb hard drives and 19-inch monitors. The other computers have smaller systems (133 MHz). This provides the NAME 4150/4155 senior design teams with access to workstations capable of supporting a number of ship design software packages summarized in Table 3.

Marine design-related software

The design related software covers the following six main areas:

1. Lines fairing.
2. Hydrostatics and stability.
3. Resistance and propulsion.
4. Structural design.
5. Finite element analysis.
6. CAD/Drafting.

The current inventory of UNO-NAME educational software is summarized in Table 3. This represents a $6000 software purchase and a $700.00/yearly fee commitment. This computer software laboratory development is quite reasonable when compared to the $650,000 UNO towing tank equipment installation [4].

NAME 4150/4155 SENIOR DESIGN CAPSTONE DESIGN CLASS SEQUENCE

The design classes NAME 4150 and 4155 are taught with two objectives. First to allow the students to understand the design process and secondly to allow the students to evaluate different

Table 4

Year	Credit	Course Description	Details
1984–1997	1	NAME 3140 COMPUTERS IN NAVAL ARCHITECTURE Prerequisites: NAME 2160 and CSCI 1201. Numerical methods. Programming of hydrostatic curves. Computers in offshore structures design. Introduction to computer graphics.	
1997–1998	2	NAME 3140 Computers in Naval Architecture Prerequisites: Naval Architecture 2160 and Computer Science 1201. Numerical methods, including function approximation, numerical integration, iterative techniques for solving systems of non-linear equations, simulation based design, computer aided design, and integrated design.	Table 5
1998–Pres.	3	NAME 3140 Computers in Naval Architecture Prerequisites: NAME 2160 and CSCI 1201 Numerical methods, Curve and surface representation Solution of equations, Use of software for hull design including hull fairing, Hydrostatic calculations, arrangement drawing and strength analysis.	Table 11

sets of solutions. Initially, in the period 1984–1994, NAME 4150–4155 students used the computer within several aspects of their design project. They prepared CAD drawings, spreadsheet calculations and used software packages to complete parts of their design project.

Then in 1995 NAME 4150–4155 was reorganized. An attempt was made to teach the students to use the computer as an integrated tool in the design process. The naval architecture fairing packages, CAD software, calculation spreadsheets and report word-processing were linked and the students used a network system in the design procedure. This experience guided later course revisions of NAME 3140 Computers in Naval Architecture.

Organization of name 4150/4155 ship design projects

In the 1955–96 NAME 4150/4155, the students formed two-person teams which selected their own projects. The projects included two container ships, a passenger catamaran, two sport-fishing boats, a high-speed powerboat, and a diving support vessel [5]. The course was organized in seven steps:

- Step I—Discussion and creation of the vessel design requirements.
- Step II—Preliminary vessel design; principal dimensions, hull geometry, hydrostatic calculations; vessel stability analysis and estimation of hull resistance; propeller design, preliminary hull structure design, weight distribution; ship motion estimates, load condition evaluation.
- Step III—Drawings; lines, preliminary arrangement, midship section; capacity plan.
- Step IV—Design revision and final evaluation.
- Step V—Executive summary.
- Step VI—Presentation at a SNAME meeting [5].
- Step VII—Preparation of the design in a professional format, namely a computer diskette.

As part of the final submittal for NAME 4155 course, each student submitted a diskette with their vita and highlights from their final design project. This diskette included drawings, graphics and an executive summary to be given to prospective employers.

NAME 4150/4155—lessons learned

The overall design experience in NAME 4150/4155 was very positive. The design projects showed the potential of using this integrated design system. The students demonstrated that they could perform a reliable, fast and consistent design. During the course evaluation, the following items were noted:

- The students were familiar with many of the software packages, but had not used them in an integrated manner.
- The software packages enabled the students to revise their design many times and achieve a professional result.
- The software packages also allowed the students to evaluate different design solutions.
- The software packages enabled the students to achieve a high quality in their final project.

During the process the following aspects were observed:

- The students groups had difficulty to establish the project schedule.
- The student teams required assistance to organize the project into a logical design procedure.
- The students do not verify the calculations and check intermediate results, so the mistakes appear in the last stages of the design.
- The lack of organizing the project design activity resulted in a lack of time and the completion of one design. They were not able to fully exploit the software capability to obtain different design solutions.

These lessons have been incorporated in NAME 4150/4155 and NAME 3140 courses.

NAME 3140 COMPUTERS IN NAVAL ARCHITECTURE

When the UNO-NAME program began in 1984, the 1 credit NAME 3140 computers in Naval Architecture lectures included computer graphics. Following the 1995–96 experience in NAME 4150/4155, the NAME 3140 credit hours were increased to two in 1997. This allowed the NAME 3140 course content to accommodate the introduction of software packages for hull lines fairing and finite element analysis. The revised course content summarized in Table 5 focused on improving the student's ability to utilize these design packages.

In 1998 and 1999, a pre- and post-assignment survey was completed by the NAME 3140 class to establish the time needed to become acquainted with the computer software and complete the assigned exercises. This survey was completed for Auto-CAD, the lines fairing software, and finite element analysis packages.

NAME 3140 student level/computer software sage survey results

A pre-assignment survey was completed during the first class. The results for 1998 and 1999 are summarized in Table 6. In 1998 when the students learned the scope of the course, the enrollment increased to 17 students. In 1999 it was 15 with one credit. The results in Table 6 show similarities from year to year. The majority of the students use spreadsheets (71%) and word-processing (64–71%) software packages. Contrary to expectations, only a few (14–20%) had previous AutoCAD experience. This is changing. AutoCAD 2000 is now being taught in the prerequisite computer graphics course.

Table 5. Organization of NAME 3140 for 2 credits (1998)

Week	Date	Topic	Assign. No.	Assignment	Software
1	Aug. 26	Introduction			
2	Sept. 2	Hydrostatics 1	1	Spreadsheet	MS Excel '98
3	Sept. 9	Hullform 1	2	Hull Drawing	Autoship A6/Fastship/Nautilus
4	Sept.16	Hullform 2			
5	Sept. 23	Hydrostatics 2	3	Hydrostatics 2	MS Excel '98
6	Sept. 30	Design			
7	Oct. 7	Design Drawing	4	Drawing 1	AutoCad R13/14
8	Oct. 14	Exam 1			
9	Oct. 21	Design Drawing			
10	Oct. 28	Ship Design	5	Database	MS Excel '98
11	Nov. 4	Ship Design			
12	Nov. 11	Ship Strength 1			
13	Nov. 18	Ship Strength 2	6	Analysis	Algor/Ansys
14	Nov. 25	Ship Strength 3			
15	Dec. 2	Wrap-up			

Table 6. NAME 3140 Computer proficiency and background survey; 1998: 14 students, 1999: 14 students

Students Background	1998 Number (Percent)	1999 Number (Percent)
Courses Completed		
2150 Introduction	14 (100%)	14 (100%)
2160 Hydrostatics	14 (100%)	14 (100%)
3120 Structure	2 (14%)	2 (14%)
3130 Marine Engineering	2 (14%)	2 (14%)
3150 Resistance Propulsion	3 (20%)	0 (0%)
3160 Vibrations	2 (14%)	0 (0%)
Software Knowledge		
None	4 (28%)	5 (28%)
Excel spreadsheet	10 (71%)	10 (71%)
Word word-processing	9 (64%)	10 (71%)
AutoCAD 13 CAD	2 (14%)	3 (21%)
Autoship Hull Fairing	1 (7%)	0 (0%)

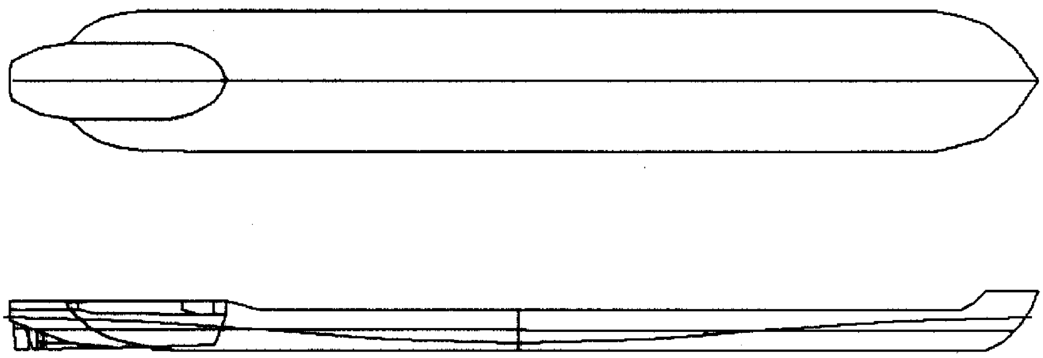

Fig. 1. NAME 3140 student AutoCAD drawing of an integrated tug-barge with sea wave. The sea wave was analytically calculated suing a spreadsheet and imported into the drawing.

NAME 3140 autocad drawing assignment (1999)

Hardware problems in 1998 resulted in several of the NAME 3140 students not completing the AutoCAD assignment. These were resolved. In 1999 the class made AutoCAD drawings of an integrated tug-barge (Fig. 1). This is a ship-shaped barge with a notched stern for the pusher tug bow. Working in groups of 3 to 4, the students completed the assignment in a week. The post-assignment survey was completed as part of the mid-term examination.

The results are summarized in Table 7. The class response correlates reasonably well with the earlier survey of student level/computer software proficiency. The 3 to 4 students with AutoCad experience completed the assignment within 2 hours while the rest of the class required 4 hours to complete it.

NAME 3140 hull fairing hydrostatics assignment

In 1998 the NAME 3140 class used the NAUTILUS software for the tug-barge hull

Table 7. Post-assignment survey results for NAME 3140 AutoCAD 14 software; Fall 1999: 14 students

	Hours			
Survey of time used for	1	2	3	4
I. Package familiarization	5 (36%)	5 (36%)	1 (7%)	2 (14%)
II. Draw Plan View	8 (57%)	6 (43%)		
III. Draw Side View	6 (43%)	6 (43%)	2 (14%)	
IV. Complete Assignment		4 (28%)		10 (72%)

Table 8. Post-assignment survey results for NAME 3140; Nautilus software Fall 1998: 17 students

	Hours					
Survey of time used for	1	2	3	4	5	6–8
I. Package familiarization		5 (29%)	8 (47%)	4 (23%)		
II. Input barge hull	11 (65%)	5 (29%)	—	1 (6%)		
III. Fair barge hull	7 (41%)	4 (23%)	6 (35%)			
IV. Perform Hydrostatics	10 (59%)	2 (12%)	4 (23%)	1 (6%)		
V. Total Time for Assignment			1 (6%)	2 (12%)	7 (41%)	7 (41%)

Table 9. Post-assignment survey results for NAME 3140; FASTSHIP Software Fall 1999: 14 students

	Hours					
Survey of time used for	1	2	3	4	5	6–8
I. Package familiarization	5 (36%)	3 (21%)	2 (14%)	4 (29%)		
II. Input barge hull	6 (43%)	4 (28%)	3 (21%)	1 (7%)		
III. Fair barge hull	4 (29%)	6 (42%)	4 (29%)			
IV. Perform Hydrostatics	14 (100%)					
V. Total Time for Assignment				6 (43%)	8 (57%)	

Table 10. Post-assignment survey results for NAME 3140; Algor finite element analysis software, Fall 1998: 17 Students

	Hours						
Survey of time used for	1	2	3	4	5	6	8
I. Package Familiarization		8 (47%)	5 (36%)	4 (24%)			
II. Draw Object		14 (82%)	3 (18%)				
III. Surface—Mesh Object		8 (47%)	5 (36%)	3 (18%)	1 (6%)		
IV. Boundary Conditions		13 (76%)	4 (24%)				
V. Total Time for Assignment				2 (12%)	2 (12%)	4 (23%)	9 (53%)

fairing exercise. In 1999 the students used the FASTSHIP software. This assignment involved:

1. Input of the barge hull.
2. Fair the barge hull.
3. Completion of the barge hull hydrostatics.

In 1998 the students were given a 4-page NAUTILUS handout to get started. In 1999 they used the FASTSHIP software tutorial. The results for the 1998 NAUTILUS, post-assignment survey are summarized in Table 8. It shows a large portion of the class needed 3 or more hours to become familiar with the package.

The offset and hydrostatics calculations were done quickly with most of the time spent on fairing the barge hull into a smooth form [6]. They modified the hull shape to achieve a desired hull block coefficient.

The results for FASTSHIP are summarized in Table 9. The students' survey indicated problems with getting started. This was in part due to the newness of the package. Unlike NAUTILUS with a number of users among the NAME student body, FASTSHIP use was relatively new. This was the main reason for limiting the 1999 fairing assignment to simply fairing the hull to a reasonable hull block coefficient.

NAME 3140 finite element analysis

The finite element analysis (FEA) assignment was handled in a similar manner as the hull-fairing assignment. Student groups of 3 to 4 members began with a 4-page start-up handout. They first analyzed in class a two-dimensional steel plate subject to non-uniform side loads. They then examined the stress distribution of the barge-tug notch interface.

Table 11. Organization of NAME 3140 for 3 credits (1999)

Week	Date	Topic	Assign. No.	Assignment	Software
1	Aug. 24	Introduction			
2	Aug. 31	Computer Packages			
3	Sept. 7	Waves	1	Wave Equation	Spreadsheet
4	Sept. 14	Auto-CAD Drawing	2	Tug-Barge Drawing	AutoCAD
5	Sept. 21	Hull Surface Analysis			
6	Sept. 28	Curvature Analysis	3	Curvature Analysis	Spreadsheet
7	Oct. 5	Hull Fairing			
8	Oct. 12	Hull Fairing	4	Lines Fairing	FASTSHIP
9	Oct. 19	Mid-Term Exam			
10	Oct. 26	Wave Interaction	5	Tug-Barge Force Analysis	Spreadsheet
11	Nov. 2	Finite Difference			
12	Nov. 9	Finite Element Analysis	6	Tug-Barge Stress Analysis	ALGOR
13	Nov. 16	Finite Element Analysis			
14	Nov. 23	Offshore Structure Design	7	Offshore Structure Analysis	Spreadsheet
15	Nov. 30	Wrap-up			
16	Dec. 9	Final Examination			

The post-assignment survey results are summarized in Table 10. It shows:

- Students are able to become familiar with the software in 2-4 hours.
- The successful surface meshing of the object took a relatively long time.
- The total time for the assignment 6-8 hours was relatively large.

The FEA survey results taken together with the AutoCAD, and hull fairing surveys resulted in the expansion of NAME 3140 in 1999 to 3 credit hours. The revised course is summarized in Table 11. The fifth assignment was expanded as a student paper [6] and continued as 3 credit NAME 4097-directed study [7].

CONCLUDING REMARKS

The shift towards software packages should be viewed as a new direction in our educational activity. It represents a certain level of educational standardization as well as a challenge to the established educational directions of naval architecture and marine engineering. For some it may become a path to establish courses on the Internet since it is based on computer software.

The evolution of the NAME 4150/4155 and NAME 3140 course has been very rapid in the past four years reflecting the impact of this software. It has been very useful since it allows our UNO-NAME students to focus on the creative aspects of their design and use the software to perform the hull form definition, hydrostatics as well as hull strength calculations. The survey data and lessons learned have provided us with insights on how this shift in our educational process is proceeding. It has been successful from the viewpoint of the industry and the professional development of the students.

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