Mallard™: Asynchronous Learning on the World-Wide Web

Michael L. Swafford, Donna J. Brown
University of Illinois at Urbana-Champaign

ABSTRACT

Recently there has been a veritable explosion in the use of the World-Wide Web (WWW) for business, personal, and educational purposes. Although its primary use has been to provide easy access to distributed information, the WWW can also be effective as an interactive multimedia educational aid. Our system, Mallard™, provides a customized learning environment for virtually any subject. Mallard™ uses the WWW to provide students with dynamic tutorials, instant and personalized feedback on homework problems, and secure online grading. This document gives a description of Mallard™; the reader is encouraged to access the demonstration at our web-site: http://www.cen.uiuc.edu/Mallard/.

1. OVERVIEW OF MALLARD™

Mallard™ is a collection of WWW documents and computer programs that provides students with a complete and customizable asynchronous learning environment suitable for virtually any subject. Mallard™ provides a secure environment within which one can organize online course material and test students via interactive quizzes. Student responses to these online quizzes are evaluated by intelligent grading programs that not only assess the correctness of a response, but also determine why an answer is incorrect (e.g., functionally correct, but not in minimal form). To allow different types of questions to be graded, Mallard™ has an open design that facilitates the seamless integration of new question types and grading programs.

For each course using Mallard™, every student has her own homepage, which she accesses via login and password. The content of the homepage is selected by the course instructor. From the homepage the student can choose among any of a number of options as shown in Figure 1: view basic course information, access a course newsgroup, send email to an instructor, read lesson material, do practice exercises, or take a quiz. Moreover, because it is her own homepage, specific information (such as grade data) can be individually tailored. Furthermore, when a student submits a quiz online, she gets immediate feedback and can access online assistance if desired.

In addition to a complete learning environment, Mallard™ has many features that are attractive from a course administration perspective. Course material can be customized by instructors for individual courses. There is a WWW interface to many administrative functions, such as maintaining current rosters, up-to-the-minute information on student progress, and posting or modifying due dates. Moreover, since quizzes are submitted and graded on-line, the instructor does not have to collect, correct, or even record grades for Mallard™ quizzes.

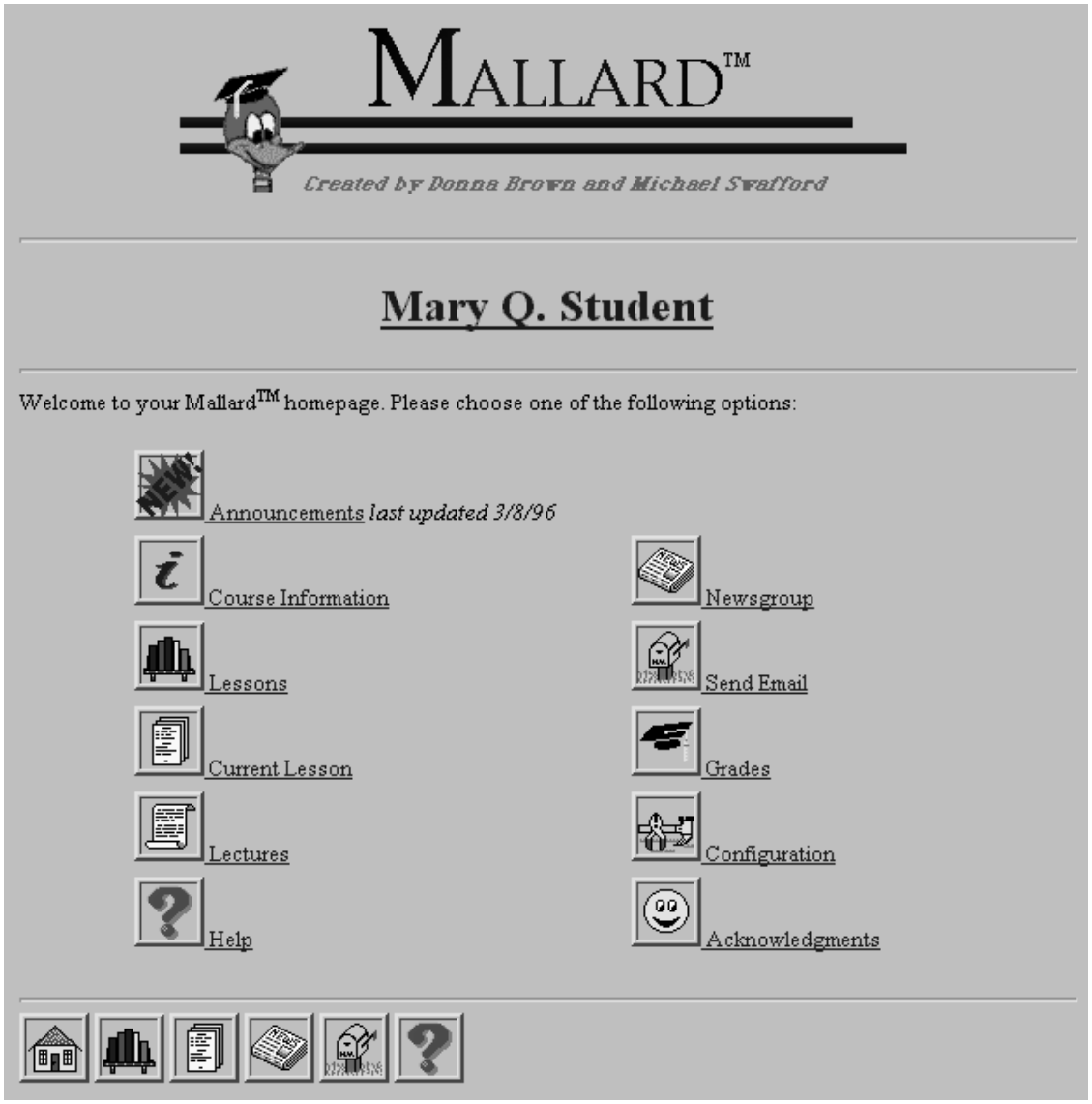

Figure 1 - Mallard™ student homepage

Compared to traditional software, use of the WWW offers a number of benefits for computer-aided education. Since there is only one copy of the course software (on the WWW server), students are guaranteed to be using the newest version. Instructors can update course content daily, as opposed to once a semester. The WWW browser is the only machine-specific component used to access the WWW, and third parties readily provide WWW browsers for virtually every type of computer. This ability to access course software from any platform was found by Carver and Howard[1] to be essential in order for students to get maximum benefit. Wheeler[2], Holtz[3], WEST[4], and Hubler[5] have also developed WWW-based educational aids.

2. MALLARD™ LESSONS

The Lessons Page conveniently displays a list of available lessons. Mallard keeps track of which lessons the student has already completed and puts check marks next to them. The current lesson (i.e., the next

uncompleted lesson) is indicated by an arrow. Each lesson also has its own page that lists which resources are available for that particular lesson (e.g., tutorials, exercises, or quizzes).

Mallard™ tutorials are standard HTML documents intended to explain course material. As such they do not contain any interactive material themselves, but they may contain sound, video, or links to interactive exercises. Mallard's™ exercise sets and quizzes, called WebQuizzes™ and WebExercises™, comprise the core of Mallard's™ usefulness as an interactive educational aid. The only difference between the quizzes and the exercises is that WebQuizzes™ are graded and used to assess student mastery of course material, whereas WebExercises™ are corrected, but are intended solely for student practice. As currently constructed, a student may attempt a WebQuiz™ as many times as she desires, but she must eventually get the WebQuiz™ completely correct to receive credit for that lesson. A student may use the "back" feature of her WWW browser to modify her answers and understand any errors, but she will not receive credit until a new WebQuiz™ is loaded and successfully completed. A similar approach to testing student mastery of course material has been successfully used in other software based educational aids, such as Oakley's CircuitTutor®[6].

Each WebQuiz™ is an HTML form consisting of one or more questions. These questions can either be randomly generated or randomly selected from multiple versions. As a result, different students will see different quizzes, and the same student will see a different quiz each time she retakes a WebQuiz™. Figure 2 illustrates a short WebQuiz™ consisting of a single question with two responses required. If a student responds that "y!" is the correct Boolean expression and leaves the True-False blank, then the graded WebQuiz™ will look like that shown in Figure 3. Notice the feedback given with these incorrect answers. The student is not simply told that the answer is wrong but is told that "y!" is not even a valid Boolean expression. Had the question requested a Boolean expression in minimal SOP form, feedback would tell the student whether or not her answer is a Boolean expression, whether or not it is functionally correct, whether or not it is in SOP form, and whether or not it is minimal.

3. MALLARD™ ADMINISTRATIVE INTERFACE

To facilitate administrative tasks, Mallard™ has four levels of user access: student, teaching assistant, developer, and administrator. The student access level is the lowest and was described in the first section. Teaching assistants have access to all the features available to students and also to features involving student grades. The developer has access to the features used to develop WebQuizzes™ but not to the features used to access and modify student grades. The administrator access level is analogous to the UNIX super-user and has access to every feature of Mallard™. Since the administrator access level is a superset of all other access levels, this section will describe the features of the administrative access level.

When a Mallard™ administrator logs into the Mallard™ system, he is presented with a Mallard™ homepage identical to what the students see but with several additional icons. These additional icons allow an administrator access to the following utilities: upload graphics, browse WebQuiz™ source files (useful for question authoring), update Mallard's™ online grade book, view log files, view server usage statistics, and access administrative utilities. From the Administration Utilities Page, an administrator can perform administrative duties such as adding new users to database files, viewing and modifying user information (e.g., when students change sections), or modifying due dates.

An important administrative task is keeping track of student progress. Mallard™ provides two WWW interfaces to do this. A progress table shows precisely which lessons have been completed by which students.

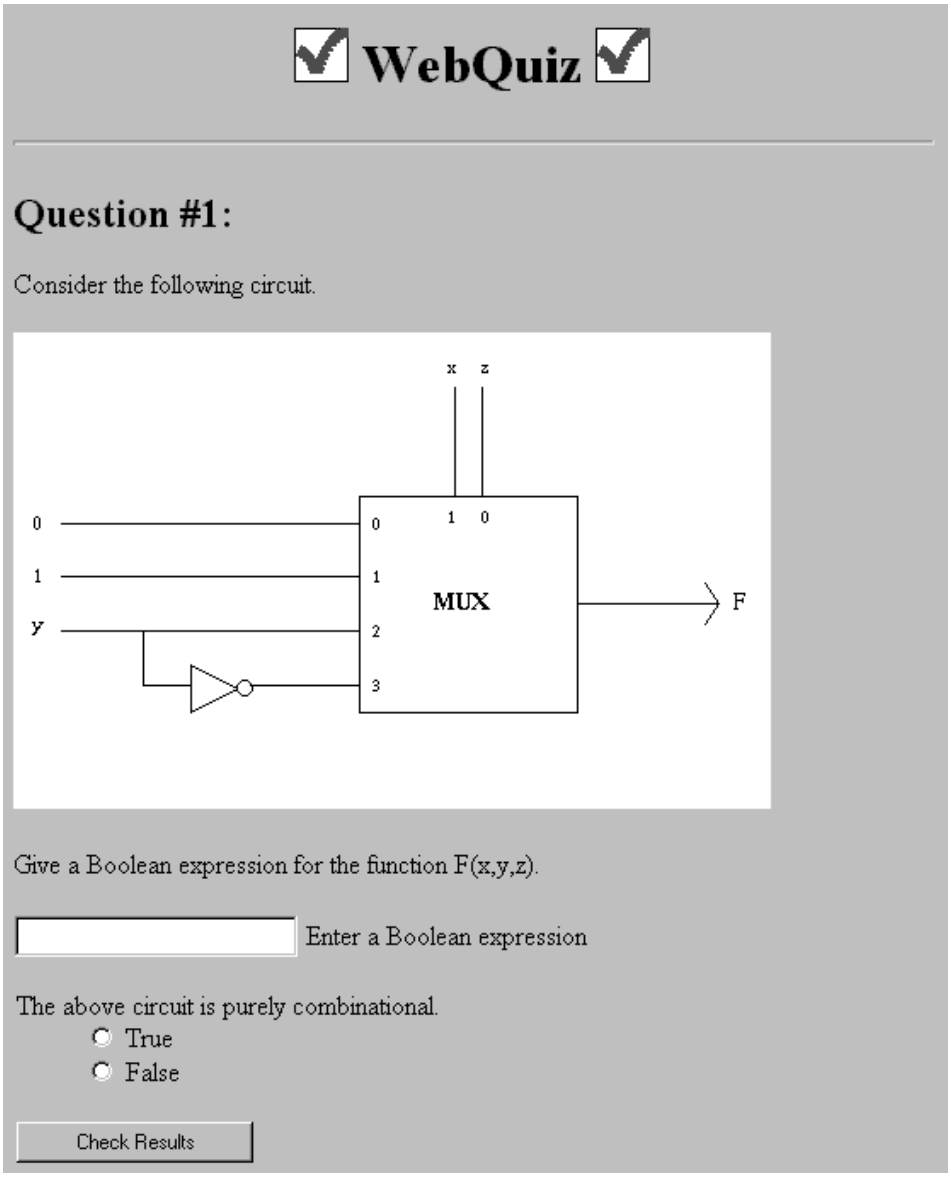

Figure 2 - A Mallard™ WebQuiz™.

Also, individual grade files provide detailed records of each student's scores for every time she attempted a WebQuiz™.

Ideally, all course lectures and assignments would be ready prior to the start of the semester. Unfortunately this is rarely the case in academe, and there is often a last-minute rush to finalize assignments and lectures. To help alleviate these problems, Mallard™ has several features to aid course development. First, WebQuiz™ authors can develop and test questions off-line and, when ready, integrate these new assignments into the Mallard™ system with the click of a button. This allows designers to test new questions and question types without fear of disrupting student access to Mallard™. Even after an assignment has been added to Mallard™, it can be flagged as “under construction” and access allowed to only non-student users. This allows other course staff members to easily view and try out new questions and answers.

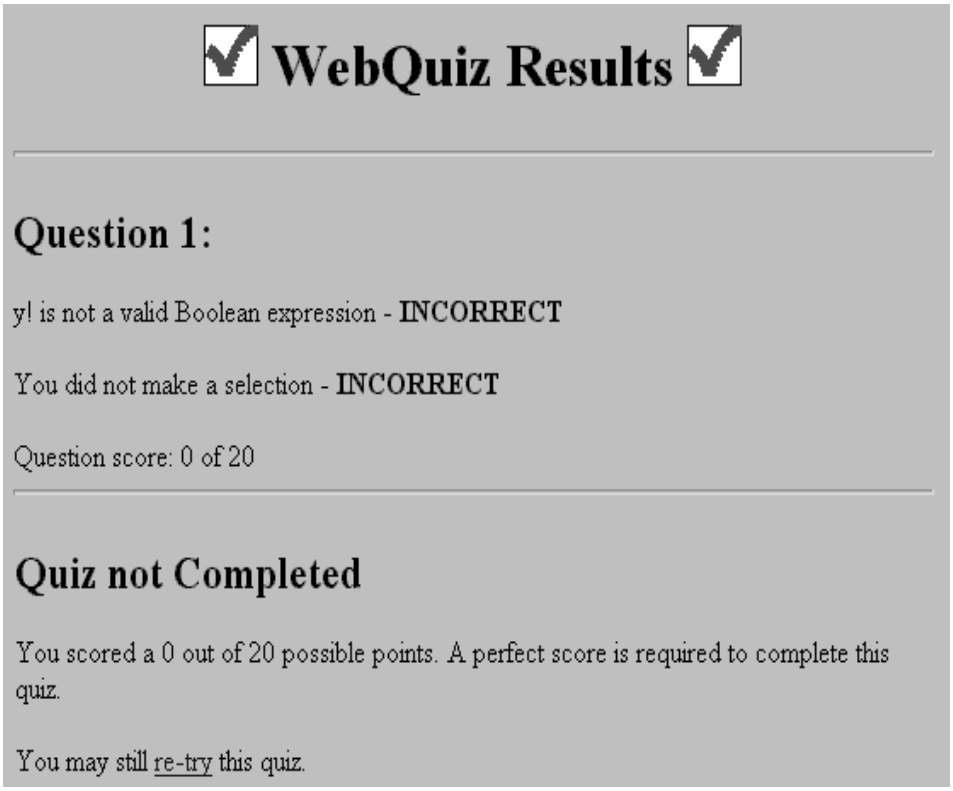

Figure 3 - Graded WebQuiz™ from Figure 2.

Developing course material and questions is very time-consuming, but Mallard™ strives to make this task as easy as possible. Mallard™ has a library of predefined useful question types such as multiple-choice, arithmetic, Boolean expression evaluation, etc. Concise programs generate and grade these questions. Thus, a question author does not have to write any programs, but can just specify the question type and supply the correct problem and solution.

4. DESIGN ISSUES

From Mallard's™ inception, security, flexibility, and expandability were key design goals. This section addresses some of these issues.

Because Mallard™ allows students to do homework problems, take quizzes, and even view their grades online, security is very important. One way in which Mallard™ addresses the issue of security is by using the Netscape Server Application Programmer's Interface (API)[7] to implement a complex user authentication scheme. Mallard™ also uses HTTPS, which is a secure HTTP protocol that uses RSA[8] public-key encryption to provide an encrypted link between the server and the WWW browser. Mallard™ also uses DES encryption[9] to further protect sensitive information such as grades.

An important part of security for any computer system is maintenance of accurate log files. These log files can be used to identify suspicious activity or reconstruct the circumstances that led to a system failure. In addition to the normal HTTP server logs, Mallard™ keeps logs of all activities and allows administrators to view and archive these log files.

Mallard™ was designed to be easily expandable. Available question types are specified in a configuration file, and a new question type can be added by writing a grading program in Perl and then simply adding a reference to this new grading routine in the configuration file. It is not necessary to modify the Mallard™ program in any way, because Mallard™ will read the new question type using a Perl interpreter at run-time.

5. CONCLUSIONS AND FUTURE WORK

We are continuing to develop Mallard™, adding features in order to make running a Mallard™ course as easy and effective as possible. Immediate plans for new features include new question types and an English language interface for writing questions. The WWW is growing at a fantastic rate, and new technologies such as conferencing software, virtual reality (VRML), and portable programming languages (Java) are being integrated into it just as quickly. Our plans are to use these technologies to improve Mallard™ and bring it to another level of interactivity.

We have one semester of experience using Mallard™, and initial response indicates it is a popular and effective learning aid for students. Specifically, Mallard™ has been used by 30 students and accessible to almost 200 others during the Fall 1995 semester of ECE290, Introduction to Computer Engineering, at the University of Illinois. There was no apparent server congestion, even though the HTTP server that Mallard™ runs on handles over one gigabyte a day in non-Mallard™ WWW traffic; this shows that Mallard™ is cost-efficient by being responsive without necessarily requiring a dedicated server. In the Spring 1996 semester, Mallard™ will be used by more than 500 students in four different courses nationwide. Interest continues to grow, and a number of other courses are being developed to use Mallard™ in Fall 1996.

We foresee great potential for WWW-based learning. Mallard™ provides such an environment. The student has access to a virtually limitless supply of problems. These problems are corrected instantaneously and, depending on the problem, hints or partial feedback can be given. The student can work from any platform she chooses, needing only access to a WWW browser such as Netscape. From the instructor's viewpoint, Mallard™ not only provides students with exercises and quizzes, but it also provides automatic correction and recording of grades. Routine administrative tasks such as adding new students to enrollment lists and changing due dates are easily handled. Mallard™ also simplifies the task of authoring new problems. We plan to continue Mallard's™ development by adding new features and making the Mallard™ user-interface as simple as possible. New WWW technologies will be integrated into Mallard™ as they become available. Mallard™ is a very useful educational tool now, and its possibilities for the future are almost limitless.

Acknowledgments: The authors are grateful for the support of the University of Illinois, the Electrical and Computer Engineering Department, and the Sloan Center for Asynchronous Learning Environments (SCALE). We also want to thank Ed Kubaitis for his help with WWW server administration issues and all the students and others who have provided input.

REFERENCES

[1] C. Carver and R. Howard, "An assessment of networked multimedia and hypermedia," *Proceedings of the ASEE/IEEE Frontiers in Education 95 Conference*, Atlanta, GA, November 2-4, 1995.

[2] D. A. Wheeler, “User Guide to Mklesson,” WWW http://lglwww.epfl.ch/Ada/Tutorials/Lovelace/userg.html, November 1995.

[3] N. M. Holtz, “The Tutorial Gateway,” WWW http://www.civeng.carleton.ca/~nholtz/tut/doc/doc.html, November 1995.

[4] Web Education Support Tools, Ltd., “Welcome to WEST,” WWW http://west.ucd.ie/, November 1995.

[5] A. Hubler, “CyberProf,” WWW http://www.ccsr.uiuc.edu/cyberprof-docs/general/, November 1995

[6] B. Oakley II, “Use of the Internet in an introductory circuit analysis course,” *Proceedings of the ASEE/IEEE Frontiers in Education 93 Conference*, Washington, DC, November 6-9, 1993.

[7] Netscape Communications Corporation, “The Netscape Server API,” WWW http://home.netscape.com/newsref/std/server_api.html, November 1995.

[8] R. Rivest, A. Shamir, and L. Adleman, “A method for obtaining digital signatures and public-key cryptosystems,” *Communications of the ACM*, vol. 21, no. 2, pp. 120-126, 1978.

[9] National Institute of Standards and Technology (NIST), “FIPS Publication 46-1: DataEncryption Standard,” January 22, 1988.

MICHAEL L. SWAFFORD received his B.S. in Computer Engineering in 1994 and his M.S. in Electrical Engineering in 1996 from the University of Illinois at Urbana-Champaign. Currently, he is a Visiting Computer Assisted Instruction Specialist at the University of Illinois at Urbana-Champaign. His research interests include networked and distributed applications, with an emphasis on WWW-based learning.

DONNA J. BROWN received her B.A. from Wellesley College and her M.S. and Ph.D. degrees from the Massachusetts Institute of Technology. She is currently a professor in Electrical and Computer Engineering and in the Coordinated Science Laboratory at the University of Illinois at Urbana-Champaign. Her research interests include the design and analysis of algorithms and asynchronous learning environments.