Finding Evidence for Design Process: Web-Based Timesheets for Architecture Students

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INTRODUCTION

Many architects and architecture students recount episodes of midnight shifts, all-nighters, and marathons of sleep deprivation with a typical unsavory relish, defining a culture that is famous across college campuses for its single-mindedness, commitment and work ethic. For many of us, the suffering that goes with overwork is a badge of honor, a rite of passage, or the measure of a true architect. However, rarely have the work patterns of architects and architecture students actually been studied in a rigorous, objective, scientific way. Many educators are left with nagging doubts reinforced by surveying empty studios and plodding progress on design projects. Do students really work hard or do they merely pretend to work hard? Is hard work correlated to good work? Do all students work hard? Do students at all schools work hard? Are there differences among the level of effort in the United States in comparison to other nations? This paper describes a research instrument that may produce definitive answers to these questions. A Web-based tool for collecting timesheets from design students can produce enough data to support definitive conclusions about their patterns of work in relation to time. The research can lead to knowledge about design process and the behavior of designers that could profoundly affect the content of teaching in design studies and how the next generation of designers behaves. The research described in this paper is a step toward a scientific approach to studio instruction as opposed to an emphasis on art.

BACKGROUND

A recent study undertaken by the American Institute of Architecture Students provides both a snapshot of the architecture studio in current times and a critique (Koch, Schwennsen, Dutton and Smith 2002). From a series of interviews, focus groups and discussions the authors reached several conclusions. Although studio is the most important and even dominant pat of architectural education, it is inadequate in preparing young architects for practice and may even foster negative habits and experiences.

Many of the criticisms in the report relate to how students in a studio setting expend their time. The report lists 14 “myths” about behavior in the studio. Five of these myths are concerned directly with time:

- The best students are those who spend the most hours in the studio.
- The best design ideas only come in the middle of the night.
- Creative energy comes from the pressure of deadlines.
- It is more important to finish a few extra drawings than to sleep or mentally prepare for the design review.
- It is possible to learn about complex social and cultural issues while spending the majority of time sitting at a studio desk.

Other myths describe physical sacrifice that may be related to overwork or a myopic focus on studio that implies a poor balance between time devoted to studio and tine devoted to everything else.

Among the recommendations of the task force is that the schools should help students better manage their time. Time management may be a crucial but neglected skill for architects. Furthermore, the task force pointed out that poor understanding of time management may contribute to low fees and low appreciation of time commitments in the profession.

The findings and recommendations of the task force are not unique. A decade earlier a study of studio culture concluded that many students engage in poor work habits and are often encouraged to do so by instructors (Anthony 1991). Students often seem to be unable to anticipate and plan the tasks needed to accomplish an objective. They often work under a condition of sleep deprivation. Major changes are implemented very late in a project, leading to a situation that requires overwork simply to reach minimal standards.

A quantitative study of time usage in design studios involved collecting timesheets from students (Clayton 2000). Although lacking generalizability due to a small sample size, the study documented long periods of inactivity followed by intensive work and excessive hours as deadlines approached. The research characterized this as a “fast and binge” pattern. Even more disappointing among the observations is that the total amount of time spent on studio was often less than a reasonable expectation in spite of these periods of high stress and overwork.

Claims by many authors of the importance of attention to time expenditures to the management of design projects have been thoroughly compiled (Soh 2003). It is fair to say that professionals recognize that time management is a necessary and even critical skill in practice. Nevertheless, explicit reference to time management skill is missing from NAAB accreditation standards (NAAB 1995, 1998, 2001).

RESEARCH IN DESIGN METHODOLOGY

A consideration of time usage in architectural design studios falls into the broader field of design methodology. This section documents other methods of research in design theory to support that the method describe in this paper is distinctive. In the past few decades, design methodology has been subjected to increasing rigor of investigation. In the decade of the 1960’s, many publications in the field made grand pronouncements based largely on personal insight, experience, and force of logic. Experts have suggested that design consists of a cycle of analysis, synthesis, and evaluation (Asimow 1962). Others have argued for the use of mathematically based optimization methods (Alexander 1964).

More rigorous methods of studying the process of design emerged in the 1970’s and 1980’s, often in response to the introduction of computer methods. Man versus machine experiments led to the introduction of synthetic experimental research methods that compared designers assisted by computers to those unassisted (Cross 1977). Researchers have analyzed videotapes of participants in collaborative design to provide insight into their design processes (Purcell, Gero, Edward and McNeill 1996; Al-Qawasmi 2000). New software has been developed based on design theory and then tested in head-to-head trials between computer-assisted designers and unassisted designers (Clayton, Fischer and Kunz 1998). In the field of product design, alternative technologies have been provided to teams in design competitions to gauge the impact of the technology (Tang and Leifer 1991).

Some research relies upon natural settings rather than purely synthetic ones. Ethnographic studies documented behavior of designers at a more personal, intimate scale (Schön 1987). Natural experiments have been conducted by observing the impact and change in process in professional organizations after the introduction of a new technology, such as that described when introducing integrated 4D modeling to construction (Staub-French and Fischer 2001). Interviews and qualitative analysis has been used to study the impacts of alternative organizational structures on design (Xia 2001).

Although all of these methods have led to perceptive and useful insights, they are almost universally limited in predictive power by small samples and restricted populations. Almost invariably, researchers in our field imply generalizations beyond what is strictly defensible from a statistical perspective. The evidence in support of any design method or even any characterization of what designers do is weak.

Web-based software has enormous potential to overcome this deficiency. The example of e-commerce applications show that the cost of participation in data collection can be lowered so substantially as to boost participation by orders of magnitude. The nearing ubiquity of networked computers in architecture schools presents educators and researchers with the opportunity to collect data about design in quantities that were impractical previously. Large amounts of data can be collected through the automatic logging of Web sites used in support of the design process (Clayton et al 2001).

The research described in this paper is a further variation on the techniques pursued elsewhere. It uses software as a data collection instrument in the psuedo-natural setting of the design studio. The participation of a large number of students who provide records to a database will allow the creation of very large datasets that can drive conclusions with a comparatively high degree of confidence. The research describe in this paper documents the concept and describes a prototype implementation. Further research will expand the data collection to a large sample.

CONCEPT OF A DATA-DRIVEN WEB SITE FOR TIMESHEETS

The large amount of data needed to support conclusions about time usage will require experiments that involve large samples of timesheets, projects, students, instructors, and schools. To draw a conclusion about student behavior in a particular class during a particular semester may require a dozen weekly timesheets each containing a dozen entries, from each of a dozen students, or somewhere in the range of 1700 entries. However, the conclusions derived from that sample could only be generalized to that class and that instructor. Perhaps it would take a dozen classes, taught by each of a dozen instructors, at a dozen schools of architecture to truly reach statistically valid conclusions over the entire range of architectural education in the United States. Such a sample would require nearly 3,000,000 records, each documenting a person, a task, and a time period. Studying time usage in architecture studios around the world would require an even larger number of records. Relational database management systems, such as Microsoft Access, Microsoft SQL Server, and Oracle, are the appropriate solution to such large datasets.

Entry of 3,000,000 records is a daunting task, except when divided up into small daily tasks by a large number of people. A Web-based interface can permit each student to enter his or her own information onto a database on a central server on a daily (or more frequent) basis. Thus the burden on any individual is only 100 or so transactions.

Data-driven Web sites have become the workhorse of serving pages on the World Wide Web and supporting e-commerce. The technology is well understood in the information technology profession and familiar to anyone who uses the Internet. A person uses a Web browser, such as Netscape or Internet Explorer, to open a form represented using Hypertext Markup Language (HTML) code. The entries into the fields in the form are posted to the Web server at a remote location and entered as records in a database. The Web server responds to the content provided by the user to compose automatically a new Web page that is posted back to the user's Web browser.

The integrity of the data entered by students may be questionable, but various safeguards can be included to help distinguish between accurate data and falsified data. In general, it is easier to tell the truth than it is to lie; most students will report their time usage accurately. Instructors should be encouraged to avoid using the amount of time spent to influence grades, as such practice would provide students an incentive to inflate their time usage. On the other hand, an instructor could count the number of entries and consistency of participation and use those statistics to influence a participation grade that would act as an incentive to report frequently. Time and date stamps of each record can indicate patterns of how students use the tool and lend indirect insight into accuracy of data submitted. Because a conscientious student would keep records up to date, one might reasonably place higher trust in data entries that are provided at regular and frequent intervals close in time to the actual expenditure, and lower trust in entries that are clustered about deadlines and represent late reporting of activities. Also, the software can collect the Internet Protocol (IP) address of the computer running the Web browser. This IP address can give a hint about the location of the computer, such as whether it is on campus or off campus. The instructor can report impressions of the students and his or her work habits that can validate or invalidate the data obtained from the students. With a very large number of entries, statistical methods can be applied to ascertain the reliability of the data.

These insights into how to interpret the data and assure reliability and validity provide guidance to how the software should work and what data should be collected.

IMPLEMENTATION

This research has gone through several pilot studies to assure the likelihood of success of a large trial. As described above, the first two stages were paper-based timesheets and electronic spreadsheet submittals. Another project then demonstrated the concept of a database as a central, collective repository for records and a Web-based interface to that database (Darapureddy 2001). Current research is focused upon developing a more robust implementation and fielding it to architecture students. This implementation is being provided as a specification to a professional software developer who is skilled at implementing data-driven Web sites. The specification, or working model, is described below.

Figure 1 shows the structure of tables in the timesheet database system.

Most of the fields are self-explanatory, but some require additional discussion. A record in “user” is associated with potentially many records in “timesheet” each of which stores a date and duration of an activity. Each record in”“timesheet” could be associated with many records in “designActivity”, each of which describes a typical design task. Each user is associated with a project that has a college, and instructor. A project can have up to five phases, such as conceptual design, or construction documents. The “accessLog,” table keeps track of the time that the user logged into the system and the IP address of the computer. The “timeExpectation” table keeps track of the instructor’s expectations for time to be spent in each category.

The user interface is conceived as a set of screens, which is common in Web-based applications. A page for creating a new account is shown in Figure 2. The screen provides access to personal data, such as name, password, email address and other identifying information. Upon logging in, a user is presented with a graphical representation of the time of activities that have been recorded for each day,

Figure 1. Relations among database tables. The relations are all of a “one-to-many” type. For example, a record in “user” can point to many records in “timesheet,” but a record in”“timesheet” can point to only one record in”“user.”

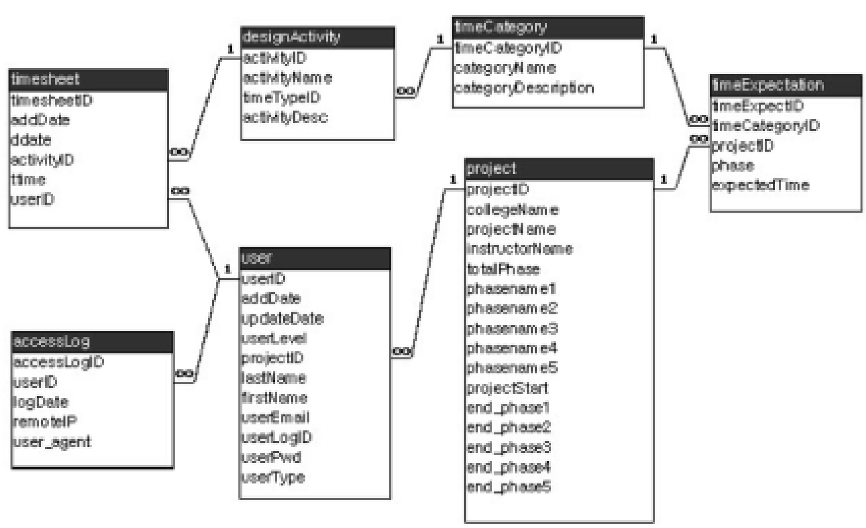


Figure 1. Relations among database tables. The relations are all of a “one-to-many” type. For example, a record in “user” can point to many records in “timesheet,” but a record in “timesheet” can point to only one record in “user.”

Figure 2. Creation of a new account.

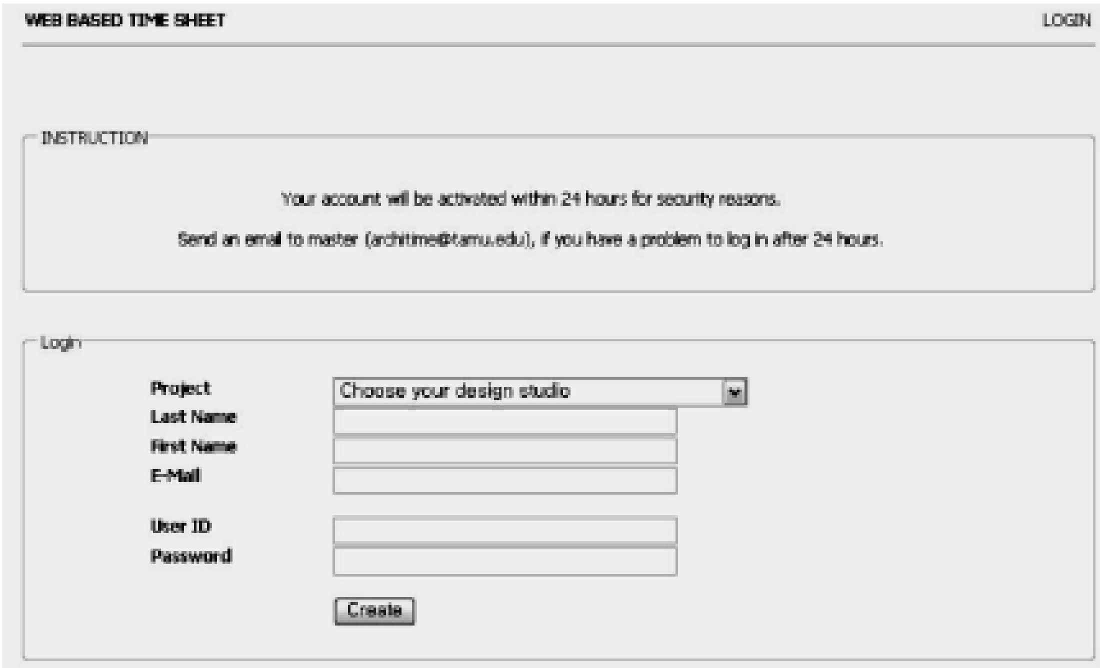
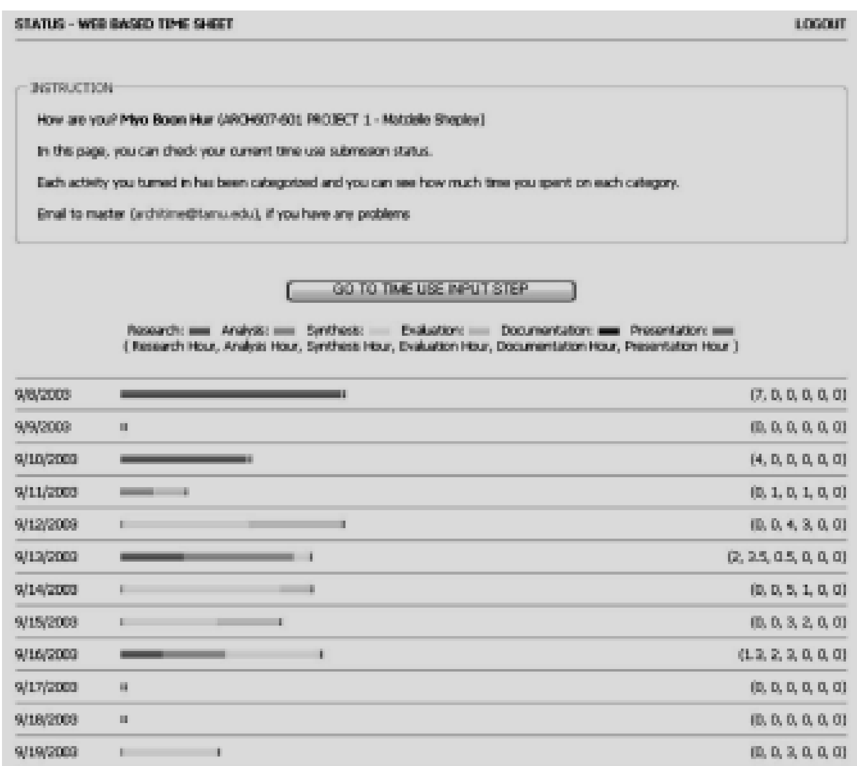


Figure 3. Time summary screen.



grouped into categories, shown in Figure 3.

Another screen allows for creating and editing entries of activities into a timesheet, shown in Figure 4. The student can choose from a list of activities that has been compiled from previous studies and provide how many hours and minutes have been devoted to that activity.

Although the input screens have didactic value in helping students be aware of time management, inspiring reflection on their work schedule, and guiding them to identify particular activities, the analytical tools are intended to have the greatest educational value. Figure 5 provides comparisons of time usage between the student, the average in the class, and the expectation of the instructor. The student can compare his or her workload to that of other students and calibrate the effort put into the class to the desired class rank. Comparison to the instructor's expectation can provide guidance to possible grade, or whether the student is working efficiently. Summaries are broken out into the categories of activity of a particular design theory, so that a student can gauge whether his or her time usage aligns with the model of the design process.

Additional screens in the current software are restricted to the instructor to support managing the class. The instructor can put in the phases of the project, the start and end date of each phase, and the time expectations of each phase. The instructor can look easily at the time records of all students and check the summaries against class averages and expectations. The instructor can also retrieve the personal data, such as email address, of each student.

Additional screens are being implemented, such as one to show weekly time summaries. This will reveal whether students are falling behind in time commitment and risk a "fast and binge" pattern. Pie charts that focus on the proportion of total time devoted to each category of activity can provide a student with guidance on whether enough attention is directed to each step in the design process.

EVIDENCE THAT CAN BE OBTAINED FROM THE TOOL

Figure 4. Timesheet input screen.

A wide range of insights into design process can be obtained by using this research instrument. At the simplest level, the software will produce answers to how much time students devote to architectural design. Total time for a project by an individual is revealed, as well as ranges of time across a class. The total duration of a project allows the time to be normalized so that many projects can be compared. Patterns of time usage are uncovered, such as whether a project is front-loaded, back-loaded or balanced with regard to effort. Comparisons can be made across projects, classes, instructors and schools to help establish norms and instructional guidelines.

The categorization of activities provides the means for testing design methodology theories. If students can easily categorize their activities by a particular theory's constructs, then perhaps that theory is natural and descriptive. Theories also postulate sequences of activities, cycles, durations of activities in a particular category, and trends. The categorized activities can confirm or refute the predictions of particular design theories with empirical evidence.

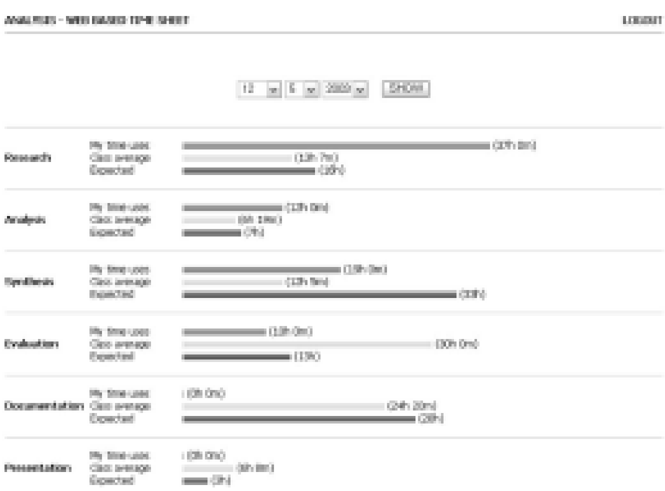
The start time of activities will allow researchers to study the diurnal patterns of work among students. Do students work late at night? Are they productive at those times?

Timestamps and datestamps on records will reveal how students report their activities. Do they report them as they work or do they try to reconstruct them many days later?

Logging the usage of each screen can provide insight into which screens are most useful or which students are most conscientious in using the software.

All of these patterns and characterizations may be compared to grades earned in a class. A correlation analysis can be conducted by the researchers rather than the instructors to avoid bias that an instructor might introduce into the grades.

Figure 5. Time analysis screen.



The use of timesheets is widespread or even universal in many design professions. This approach to studying time usage by design students can be applied in mechanical engineering, structural engineering, product design, aerospace engineering or many other fields. A study across those disciplines can help define universal principles of behavior in support of improved design quality. Implications to cognitive science will arise out of such a broad study.

CONCLUSIONS

The use of data-driven Web software for studying time devoted to design activities is a novel and very powerful research method. It has the potential to dramatically increase the sample size for studies and support conclusions for greatly expanded populations in design methods research. It can provide empirical evidence for effective behavior by designers and thus may have dramatic effects on design education. Use of the software can begin to remedy the problems of poor time management in design studios.

As design instruction moves toward a situation of universal and ubiquitous access to computers, researchers gain new ways to collect empirical evidence for students' behavior and methods. It becomes conceivable to identify effective methods and approaches as well as ineffective ones. The traditional model of design as a mysterious behavior governed by innate talent may be replaced by a model of design as a skill and set of behaviors that can be taught.

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