Avoiding Delays in Graduation: Efficient Education Planner

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Abstract

For a student, planning the set of courses to take to fulfill degree program requirements is a complex task. The student must have knowledge about degree plan requirements, course availability, possible unwritten detailed constraints, and the proper sequence of classes, in order to complete a reliable plan. For example, foundation classes, such as math and language, should be taken prior to other classes. As another example, the loading of classes must be considered particularly if a student is working full time. He/she probably should complete all of the language classes in sequence before progressing to math in order to allow the student to build appropriately on the information learned. If a student is not working and can take a full academic load, then he/she can take language, math, and other classes in parallel and in their proper sequence. As a final example, many classes are not available during the summer and some classes are only available during one course term a year; so, it becomes essential to develop a long-term education plan.

In order to assist a student in forming a long-term plan, a Web-based application called CourseSelect has been developed at Texas Tech University in the College of Engineering. CourseSelect works by allowing the student to select their major in order to receive a table of information containing degree requirements. The student may select options to complete the final course list to be used for the degree as well as according to individual interest. Next, the student selects the minimum number of courses to be completed each semester (rate of semester loading) and the semester and year to start the plan. As a result, the student is presented with a listing or long-term plan of courses ordered by semester and the hours per semester until the planned graduation. Constraints on the plan are included, such as warnings of pre-requisite violations or a course being scheduled when not offered. The student has the option of customizing the long-term plan by moving courses to other semesters to attempt to eliminate the warnings. The long-term plan is stored for use by the student so that it is available for course

term scheduling. Hopefully, in this way, the student incurs a lower or minimum time and cost for education.

Introduction and Context for Work

The cost of higher education is expensive and rising partly because of the time required to complete the education (opportunity lost to work) and partly due to the direct costs of tuition, fees, housing, and food. While higher education is generally a good investment, most students can reduce their cost of education by carefully planning their academic career. For example, students change majors often at the expense of losing courses already completed that do not count toward the new major. The change of major thus costs in longer time to graduation and the expense of the now unusable courses. As a reasonable first step at minimizing the cost for a college education is the careful analysis and selection of a major that fits the individual's personal interest. Early analysis of major can save one, two, or more course terms of time in college and save several thousands of dollars in direct cost and opportunity losses.

In selecting a major, some methods, such as AIM, can cost several hundred dollars. Others, such as the ASVAB (Armed Services Vocational Aptitude Battery)[1], are inexpensive enough to be used in public high schools, but require about an hour to administer, one to two weeks to mail and retrieve results, and another one-half hour or so to review and discuss results. A simpler process available on the Web at Texas Tech University (TTU) is provided freely through E-COACH[2] which requires about 10 minutes of input with immediate results where majors are ordered from best to worst fit according to individual personality and interest. In addition, E-COACH can be used by people about 12 years of age and older.

Another tool, QUICK Scheduler[3], was developed in the TTU College of Engineering (COE) to shorten the advising process and to provide students with an academically efficient schedule. QUICK requires that the student know what classes to take so that it can pick the class sections and resolve conflicts with other classes, work, and activities. It provides a short-term plan—a schedule for the next course term. It does not provide a long-term education plan.

Thus, a tool to help students develop a long-term plan based on their major would be of immense help to students especially in evaluating the impacts of critical decisions, such as changing major or working full-time. The tool needs to be dynamic to regenerate long-term plans after a student fails/drops a course or makes degree changes. The tool needs to enable the student to look ahead and plan to take classes during semesters when courses are normally available. It needs to consider pre-requisites and co-requisites as well as provide a reasonable pace for the student's major, need to work, and desire to complete co-op or intern experience.

Concept for Development

The tool for generating a long-term plan of courses that should be taken each semester until graduation is called CourseSelect and several factors were taken into consideration in its design. For example, it needs to be general enough to deal with majors having long sequences of pre-requisites, such as engineering. It should be general enough to deal with majors that have many choices and few pre-requisites, such as general studies and history. When the major does not

limit the ordering of courses, it should order classes from low course numbers to high course numbers so that formula funding from the state is optimized. It needs to provide the plan with reasonable input of information from the user and provide results quickly after input is completed. It should facilitate editing of the plan. It is also desirable to save the final plan so students may use it later for scheduling classes according to the plan and to allow departments to forecast demand for classes.

CourseSelect needs to respond to the individual's desired rate for completion of their classes. For example, at a lower extreme boundary condition, if a student is working full-time and only able to take one class a semester, the sequence for classes should be different from the student taking a full load. The one-class per semester student probably should take English Composition I then English Composition II before moving to the math courses. This plan allows the student to build on the material from the previous class as they go into the next class in sequence. If the one-class per semester student majored in engineering, they should take all of their math classes in sequence to maximize the recall of information for the next class. This logic eventually causes the student to take some upper level classes before other lower-level classes at the expense of formula funding for the university, but increases the probability of academic success for the student. Although improbable, at the other higher extreme boundary condition where the student can take all classes in one semester except for classes that build on pre-requisites, the sequence of pre-requisite classes ultimately determines the minimum number of semesters it takes to complete a degree. It helps when departments minimize long sequences of pre-requisite classes where possible to enable students to graduate in a few semesters. Certainly, most students operate somewhere between these two extreme boundary conditions. CourseSelect, however, must be capable to adjust the plan as either of these boundary conditions is approached. In contrast, the common plan on paper in higher education catalogs is not right for some students and must be modified by students and their advisor before graduation.

Finally, with the long-term plan generated electronically using CourseSelect, it should be possible to translate the plan to courses at a specified junior or community college. Hence, CourseSelect should have the ability to utilize junior or community college articulation agreements and to provide competent, economical advising at a distance. As a result, engineering majors may be kept from completing all core requirements at community colleges without completing the foundation math and physics classes needed to advance to upper-division classes.

Development Process

Three major tasks had to be completed to develop CourseSelect.

- Task One: an algorithm had to be developed to provide the course ordering.
- Task Two: a connection had to be established to the university's system to retrieve degree audit information.
- Task Three: an editing function had to be developed to allow the student and the advisor to interact with the system, such as choosing to attend summer school or move classes between semesters, and solve scheduling problems.

By choosing to let the student use editing to solve scheduling problems, computer time is minimized and the student is encouraged to take ownership of his/her long-term academic plan.

Course Ordering and Checking for Problems

The course ordering algorithm starts by ordering courses from low number to high number. The algorithm also counts the number of hours of course work from each department and sets a priority for courses based on this ordering. English courses by default are given top priority for courses within the first 1.5 years (45 hours) of classes because of the value in almost all other classes. Math courses by default are considered the second priority for lower level classes. The student can specify a third priority department, such as physics for engineering physics majors, but it is usually not necessary to use a third priority department. The department with the most classes becomes a priority department because it is probably the major. The algorithm works its way through these priorities as it fills each semester with classes. The algorithm has a variable associated with each major that limits the number of classes that can be taken from one department in any given semester for lower level classes. A value of five hours seems to work well for engineering because it also generally reduces prerequisite problems. Students are also prevented from investing too many hours into one department until they become sure about their major. As an exception, architecture majors are expected to take a minimum of nine hours per semester for the first two semesters to see if they are artistic and can draw.

The algorithm goes down the list of prioritized classes and populates the semester until the five-hour limit is reached. It then moves to the next semester and continues until all of the lower level English classes are scheduled. The algorithm does the same thing with the math classes (second priority) starting over with the first semester. When there is insufficient room for a course in a semester, the algorithm skips to the next semester.

When all courses are scheduled, the algorithm makes a pass through the classes referencing the co-requisites, prerequisites, and historical record of class offerings. A printout of results from the initial algorithm development is given in the Appendix. The output is abbreviated as follows: fo-fall odd semester, fe-fall even semester, so-spring odd, se-spring even, s1 summer 1, s2, summer 2, and s3 summer 3 (long summer trimester). Course abbreviations should be self explanatory. Degree requirements for Civil Engineering as used in the Dean's Office are also shown in the Appendix. In deciding how to resolve warnings, such as pre-requisite violations, it became clear that some warnings would be very difficult to automate. Examples include last full semester, senior standing, and math 1321 pre-requisite for ctec 2301. Most engineering students start above trig (math 1321) and, thus, would not have math 1321 in their record as having been fulfilled. Even senior standing can be misleading. The intent is to be a senior in terms of civil engineering courses, but dual majors may have enough hours to be classified as a senior by the system, but not be a senior in terms of civil engineering courses. These questions are left for the advisor and student to resolve.

Although an initial attempt was made to write an algorithm to solve all problems, it became clear that the algorithm was slow, taking between 15 and 20 seconds to run. A simpler alternative algorithm was developed that now finishes in less than one second. In addition, there is value in the student being involved with the advisor as a coach to look at various alternatives while the plan is edited to solve problems.

Retrieving System Information

The most difficult part of development is the retrieval of information from the university system computers. Unfortunately, the degree audit system contains fragmented information because many departments have not debugged it. Although much work has been done to put missing information into place, still the lack of information has not been fully resolved. It might be better to have entered degree requirements manually for each of the degrees offered though the College of Engineering and not attempted to serve the rest of the university community.

The good news is that several of the degrees in engineering are getting close enough to be useful to both the student and the advisor. A few early adopters in the college will begin using it when their degree is ready. CourseSelect will assist them with the policy of encouraging students to graduate on time. CourseSelect enables the student to have a detailed plan that can easily be modified to fit the changing needs of students: bad grades, changes in major, co-ops, internships, financial crises, and family crises. If a few departments use CourseSelect successfully, others may demand the same service and more pressure will be placed on the system to make the retrieval of information easier and more complete.

Editing Function

Editing allows more flexibility in the long-term plan. When a course is in a wrong semester, the user looks over the list and moves it to a semester that solves the problem. If that semester is overloaded, the user moves a course back to the semester from which the first course was taken. Editing is one of the most recent additions and is still in the development/test phase. Thus, it is too early to discuss much of the editing function. The algorithm for ordering has the ability to skip semesters and, thus, can use one summer or two summers or even skip a long semester for co-op. A change with editing is shown in the results section.

Development Results

CourseSelect is Web-based software that runs on Microsoft's Internet Information Server 6.0 on the Microsoft 2003 Server platform. Another Microsoft 2003 Server platform runs Microsoft's SQL Server 2000 which is used to hold local database information. The software is written in C# with Microsoft's ASP.NET using Microsoft's Visual Studio 2003.

Although CourseSelect is still in development, it is mature enough to show the input functions and the generated results. The student starts by selecting the college and the degree of interest offered by the selected college as shown in Figure 1. The catalog year is also selected on the first Web page (Texas Tech has a time window of 7 catalog years on degree plans). The program is able to adjust for any changes made in degree requirements over time.

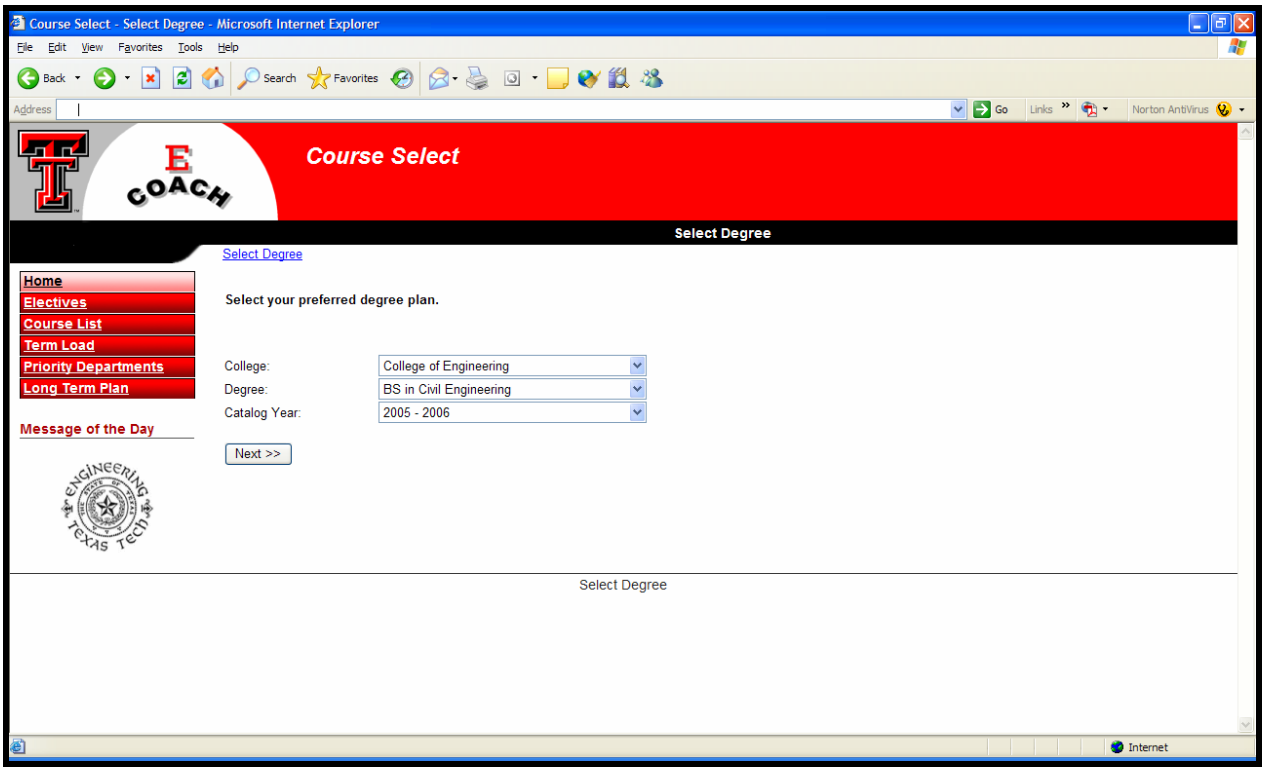

Figure 1. Selection of college, degree plan, and catalog year.

A Civil Engineering Bachelor's Degree within the College of Engineering is selected for the example that follows. When the student selects the 'Next' Button in Figure 1, the program provides the list of degree requirements shown in Figure 2. The list contains the degree plan requirements and areas of the degree plan where a choice must be made. In addition, the number of hours, the number of courses, and the number of groups to satisfy the requirement is shown. The requirement (hours, courses, and groups) appears in red, green, or blue color. The red color indicates that the mentioned requirement is not yet met. The green color indicates that the requirement has been met. The blue color (to be implemented) indicates that the requirement has been met, but also exceeded—a less than optimum plan. The green color also highlights requirements with no choice for which CourseSelect made a default selection. For example, the 'English' degree requirement in Civil Engineering has two required courses with no alternatives.

Next to each degree requirement in the listing is an 'Edit' Button. Upon clicking the button, the student gets a screen displaying the list of available courses that he/she can take to satisfy the listed requirement and the list of selected courses, if any. If there are no choices available for the student, then the courses appear under the selected list. If there is a choice as in the case of the 'Oral Speech' degree requirement for Civil Engineering, the student makes his or her selection by clicking on the desired course and then selecting the arrow button that moves the course to the selected courses list as shown in Figure 3. A course may be removed from the selected list as well.

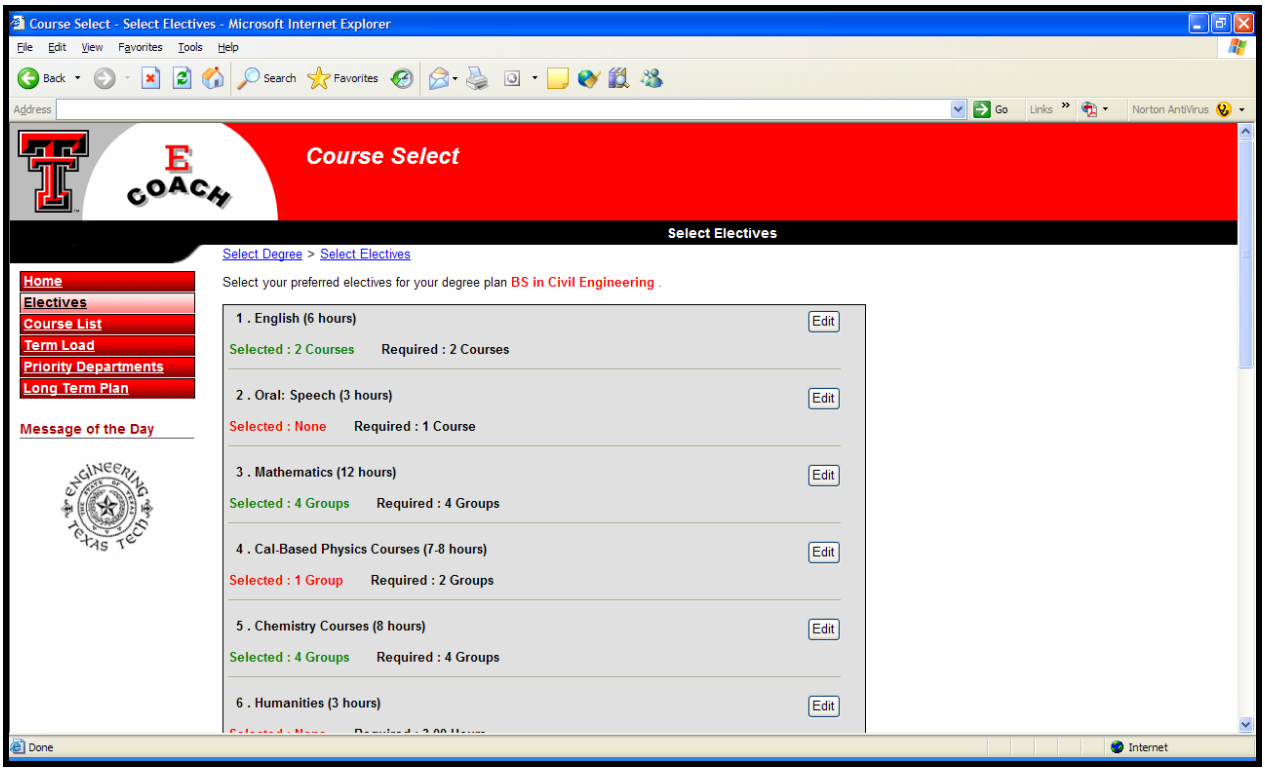

Figure 2. Listing of degree requirement groups, courses, and hours.

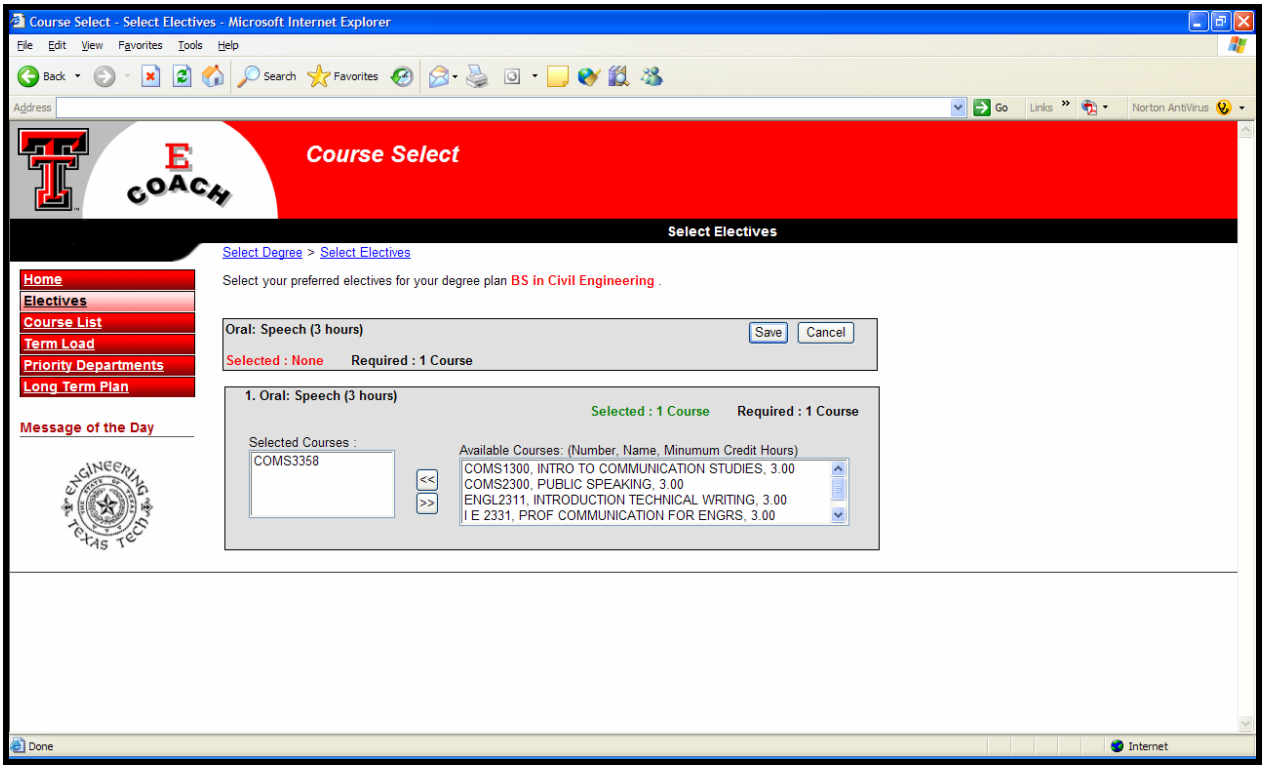

Figure 3. Illustration of the course selection feature.

When all of the requirements are colored green or a combination of green and blue, then the student moves to the next step at which a list of courses is provided that meets both the degree requirements and the individual's interest as shown in Figure 4. The list does not indicate what order the courses should be taken; it only provides the list of specific courses needed for the degree. Note that a box is provided for the student to indicate if a course has already been completed. It is anticipated that eventually the program might retrieve this information from on-line transcript data. Manual entry is needed for the student that transfers to Texas Tech University at the last minute or completes a course in summer school away from the university where the transcript information for the course or courses has not been entered into the university system. For efficiency and clarity, the software only plans uncompleted courses.

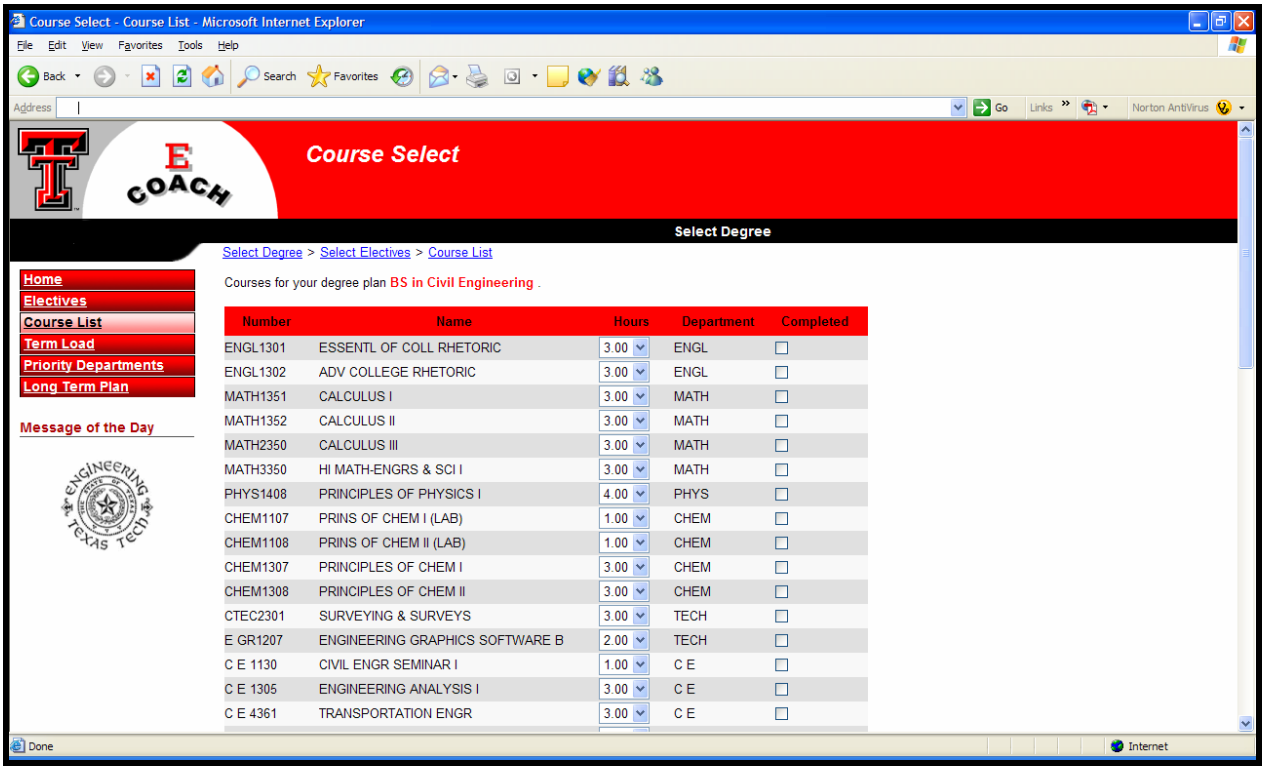

Figure 4. List of courses required for completion of Civil Engineering degree plan.

At the next step, the student selects the term that the long-term plan is to start. The student also selects the minimum number of hours to be taken during each type of semester. A zero value indicates that the semester is not to be used. Eventually, the student will be able to schedule individual semesters for each year so a student can do summer school the first or second year and not use summer school in later years. The input of this information is shown in Figure 5.

As discussed earlier, the program schedules English and Math courses as priority courses because students use them as foundation information, knowledge, and skills in other classes. The student may also select one other department as a priority department. This selection is made on the Web page shown in Figure 6. A selection of Physics, for example, would cause Physics courses to be scheduled after English and Math, but before other courses. Although the figure shows a 'Physics' selection, 'NONE' is chosen.

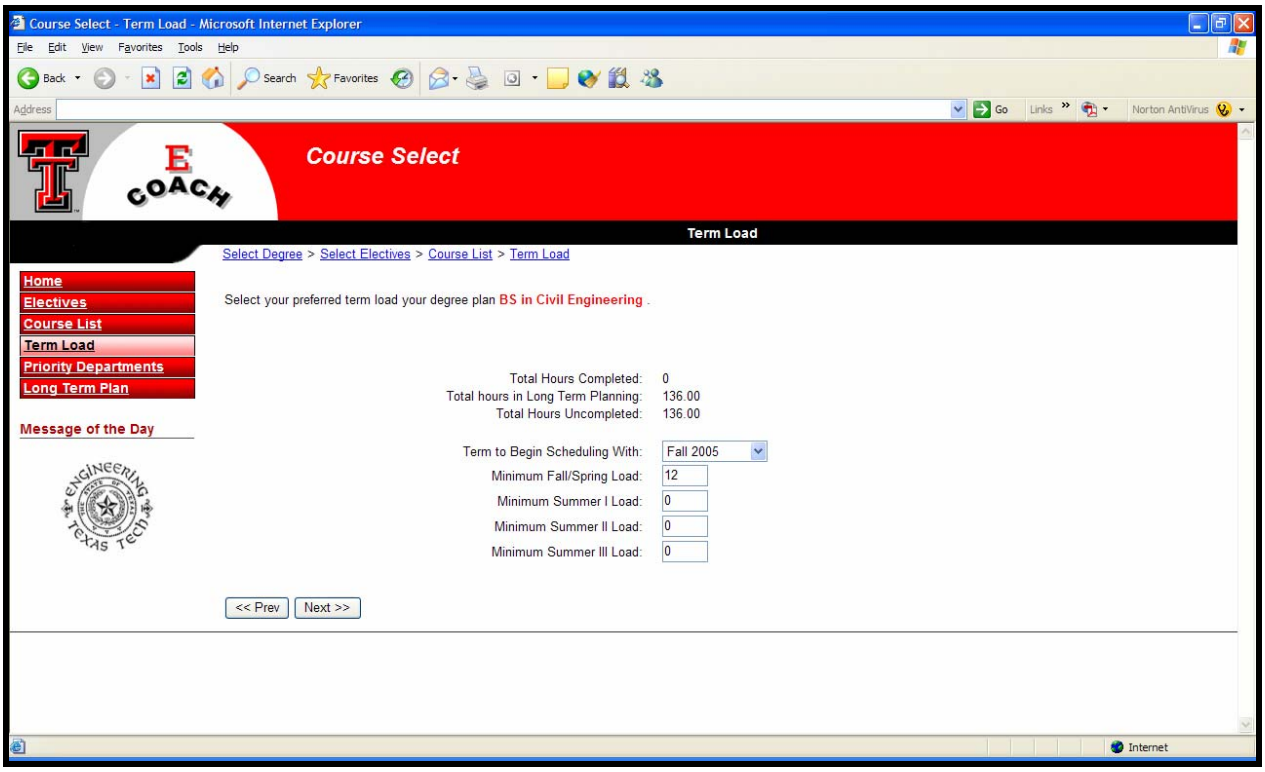

Figure 5. Input of minimum number of hours to be scheduled during each semester type.

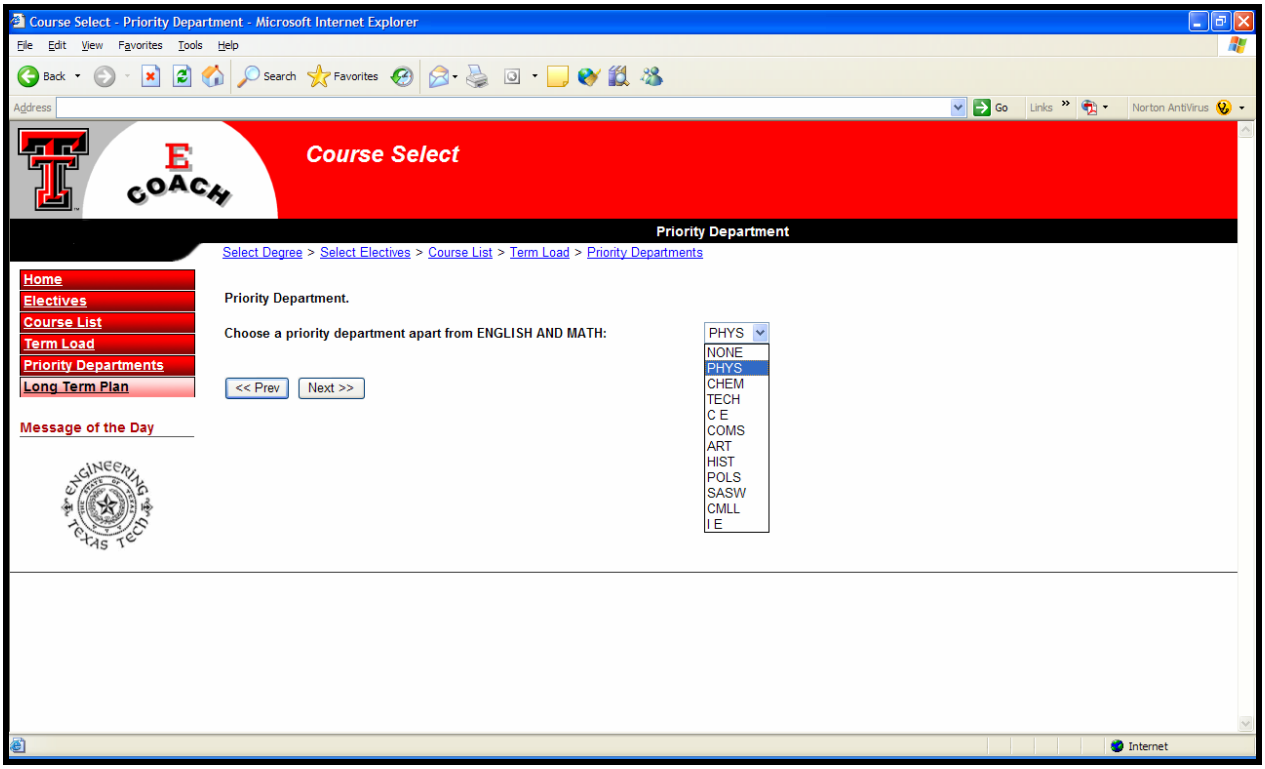

Figure 6. Selection of priority department in addition to English and Math.

The long-term plan is given in Figure 7 showing each set of courses for each semester. Ultimately, CourseSelect will give prerequisite courses underneath the 'Message' column, such as 'Pre-Reqs: MATH1350, MATH1550' for MATH 1351. Students can also meet the prerequisite requirement for MATH 1351 with a score of 7 on the university math placement exam. The university system checks this information as the student registers for classes. The university math placement exam results are not entered as a warning in the data set used to develop the ordering algorithm. CourseSelect will print the warning if it is detected from the system.

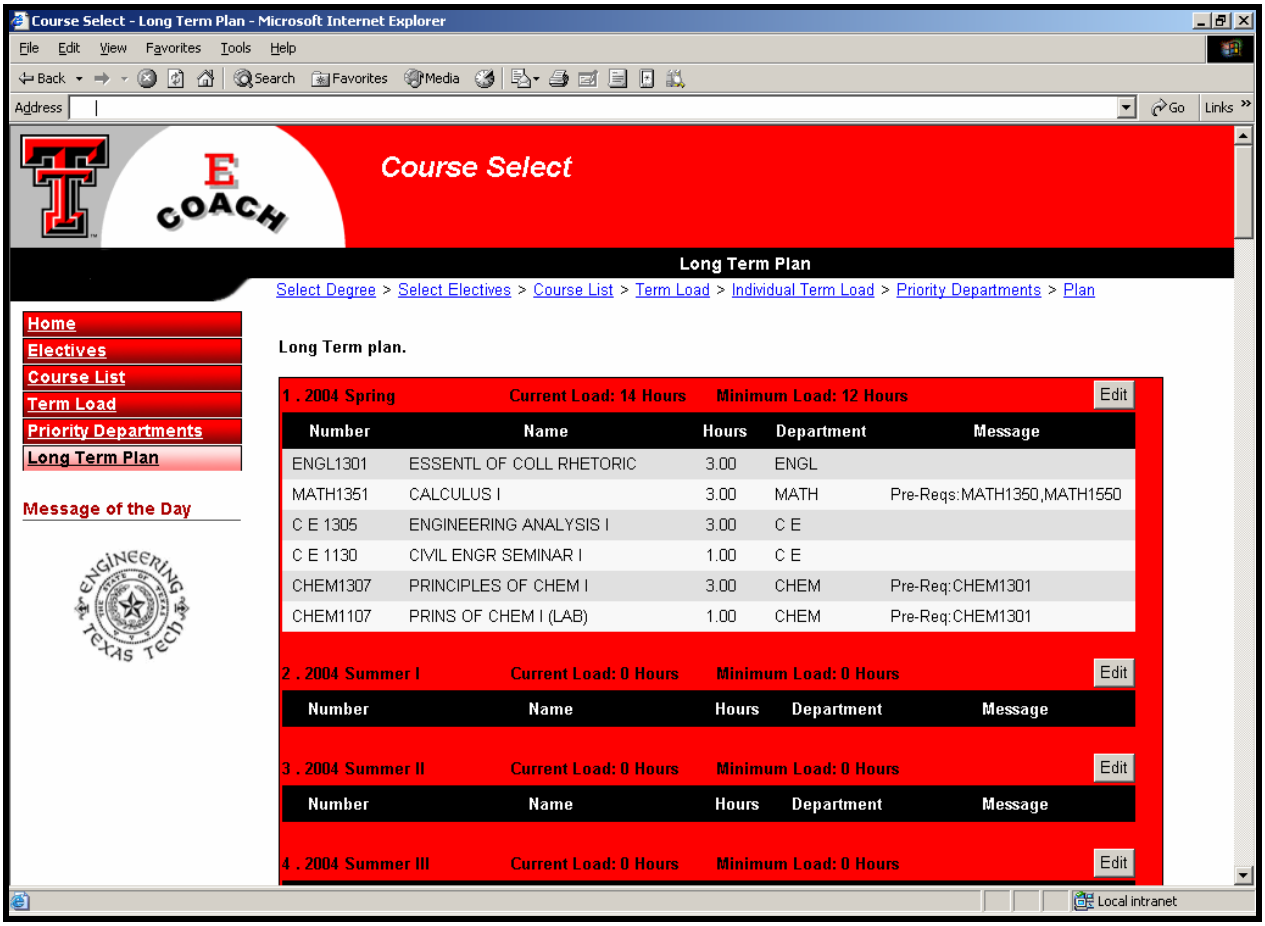

Figure 7. Sample output with courses ordered and divided into semester with warning messages.

Currently, CourseSelect does not have the history of class offerings. While this is relatively easy information to generate with a report, it is on a different part of the university system and requires special work to retrieve the information. A program, however, may be written that reads the course offerings during the last year and updates the historical offering codes after each semester has become official in the university system.

The early version of editing is shown in Figure 8. The student selects the semester on the course to be moved. Provision is also made to move another course out of the receiving semester in order to maintain a balance in hours during each semester. Certainly, the student could destroy all benefits from the program if they over edit and do not adhere to the built-in ordering process.

The advisor is expected to be involved in the editing process and to be copied on the final long-term plan. The 'Copy-To-The-Advisor' function will be developed at a later date.

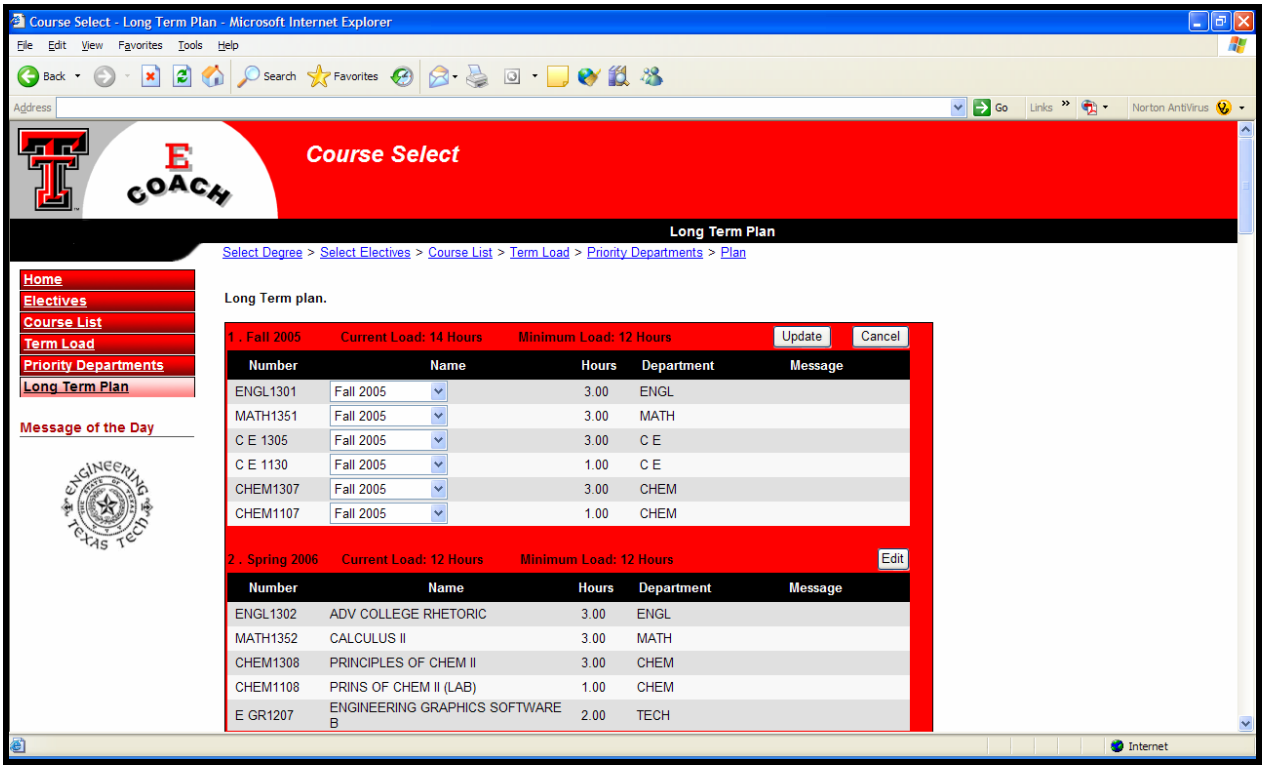

Figure 8. Example of the editing function to move courses from one semester to another.

Summary and Conclusions

Although still in development, CourseSelect works well in limited form for some majors in engineering. As the degree audit information is filled into the university system, CourseSelect will be enabled to offer more complete long-term plans to students seeking to ensure their timely education. The key components that are working are the selection of the degree, the selection of course options, the selection of the term and semesters to use in the long-term plan, the additional selection of a priority department, and the generation of the long-term plan without warnings. The figures shown in the previous section were all generated by CourseSelect in sequence. CourseSelect has the potential to become a major advising tool.

Acknowledgements

We thank the students who have worked on CourseSelect in Dr. Susan Mengel's software engineering courses. We also thank the employees in the university computer system who helped us connect to the university's master data. We gratefully acknowledge the support given by the grants from the Texas Coordinating Board to develop this software.

The Web site for CourseSelect is not provided since it is still under development.

In the published literature, we have not found the description of a similar tool to CourseSelect. We have found only a few Web links for degree plan assistant concepts or secure planners that cannot be accessed publicly.

Bibliography

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Biographies

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Mr. Santhosh Swaminathan is a Master's of Computer Science student in the Computer Science Department in the College of Engineering. He has participated in several software development efforts in the College including Civil Engineering and the Associate Dean's office with the innovative Bridge program headed by Mr. John Rivera. He is currently the head programmer for CourseSelect.

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Dr. Susan Mengel is an Associate Professor in the Computer Science Department at Texas Tech University. She has served on the IEEE CS and ACM Computing Curriculum Steering Committee and the IEEE CS Board of Governors. She also is the undergraduate curriculum committee chair in the Computer Science Department.

Appendix

The output below is that of the stand-alone algorithm for a Civil Engineering Bachelor's Degree long-term plan. This algorithm was developed apart from CourseSelect in order work as many problems out as possible before including it in CourseSelect. Degree plan requirements are attached at the end.

```
_____________________________________________________________________
Semester 1    fo
Hours  17
engl          1301
math          1351
c e           1305
c e           1130
chem          1307
chem          1107
pols          1301

_____________________________________________________________________
Semester 2    se
Hours  17
engl          1302
math          1352
chem          1308
chem          1108
phys          1408
art           1309

_____________________________________________________________________
Semester 3    s1
Hours  8
math          2350
e gr          1207
c e           2301

_____________________________________________________________________
Semester 4    s2
Hours  7
math          3342
c e           2101          Course unavailable this semester
                            Always available except Summer
pols          2302

_____________________________________________________________________
Semester 5    s3
Hours  0

_____________________________________________________________________
Semester 6    fe
Hours  16
math          3350
phys          2401
hist          2300
hist          2301
phil          2300
```

Semester 7	so	
Hours 17		
ctec	2301	
		Pre-request math 1321
c e	3302	
c e	3303	
c e	3103	
		Pre-request c e 3302
c e	3305	
c e	3105	
		Pre-request c e 3305
c e	3309	
		Pre-request c e 3305

Semester 8	s1	
Hours 0		

Semester 9	s2	
Hours 0		

Semester 10	s3	
Hours 0		

Semester 11	fo	
Hours 15		
c e	3321	
c e	3121	
c e	3440	
c e	3341	
c e	3354	
		Co-request statistics
c e	3171	

Semester 12	se	
Hours 16		
c e	3372	
i e	3301	
petr	3308	
c e	4101	
c e	4321	
c e	4330	
		Co-request last full semester

Semester 13	s1	
Hours 0		

```
Semester 14   s2
Hours  0


Semester 15   s3
Hours  0


Semester 16   fe
Hours  14
c e           4331          Unknown availability; check with department
c e           4342
c e           4343
c e           4361
c e           4292
                            Pre-request senior standing
```

Date Checked_____ By_____

NAME_____ HRS. LACKING_____

Curriculum for Bachelor of Science in CIVIL ENGINEERING -- 2004-2005 Catalog

ENGL

1301

1302

2311

MATH

1351

1352

2350

3350

HIST

2300 or _____

2301 or _____

CE4321,
POLS

1301

2302 or ____

CHEMISTRY

1307

1107

1308

1108

PHYSICS

1408

2401

E. GR.

1307

CTEC

2301

E E

3302 (2304)

I E

3301

M E

2322

ELECTIVES

**Humanities - 3 hrs.

_____

**Visual & Perf. Arts-3 hrs.

_____

Design - 6 hrs.*

_____

_____

3 hrs – COMS+

_____

C E ___

1130

1305

2101

2301

3103

3105

3121

3171

3302

3303

3305

3309

3321

3341

3354

3372

3440

4292

4293

4330 STATISTICS - 3 hrs #

4343 _____

4361

MINIMUM HOURS REQUIRED FOR GRADUATION: 135 Hrs. +
****(3 hrs—Multicultural Req.)**

*Design: choose from ENVE 4399, 4342 & 4353

+COMS: 1300,2300, 3358, CHE 2306; HDFS 2320; MGT 3373; PETR 3308 or other approved by Dept.

#Statistics - choose from: IE 3341 or MATH 3342

COURSES NOT USED IN THIS CHECK:

_____

_____

_____

Foreign Language: 2 semesters required
if not completed 2 years in high school

3/03rev