Work in Progress: Year Two of Analysis of the Impact of a Web-based Student Dashboard for a Multi-agent Approach to Academic Advising

Dr. Oscar Antonio Perez, University of Texas, El Paso

Mr. Oscar Perez received his PhD in Electrical Engineering from the University of Texas at El Paso (UTEP) with a special focus on control systems and data communications. He was awarded the Woody Everett award from the American Society for Engineering Education August 2011 for the research on the impact of mobile devices in the classroom. Dr. Perez has been teaching the Basic Engineering (BE) – BE 1301 course for over 9 years. Lead the design for the development of the new Basic Engineering course (now UNIV 1301) for engineering at UTEP for the Engineering, Science and University Colleges. Developed over 5 new courses, including UTEP technology & society core curriculum classes specifically for incoming freshman with a STEM background. Dr. Perez was awarded the 2014 “University of Texas at El Paso award for Outstanding Teaching”. Dr. Perez has thirteen years of professional experience working as an Electrical and Computer Engineer. Leads a team to provide technical support to faculty and students utilizing UGLC classrooms and auditoriums. Dr. Perez is committed to the highest level of service to provide an exceptional experience to all of the UGLC guests. Dr. Perez strongly believes that by providing exceptional customer service that UGLC patrons will return to make use of the various services the university offers. Mr. Perez enjoys working on the professional development of the students’ employees at the UGLC. He shares with his student employees his practical experience in using electrical engineering concepts and computer technologies to help in everyday real-world applications. Dr. Perez has worked with the uTeach and Tech-e camp programs at UTEP since their creation to streamline the transition process for engineering students from local area K-12 schools to college by equipping students and their teachers with teaching strategies and technologies each summer. Oscar enjoys teamwork, believes in education as a process for achieving lifelong learning rather than as a purely academic pursuit. He currently works on maintaining, upgrading and designing the new classroom of the future model at UTEP. Dr. Perez is inspired because he enjoys working with people and technology in the same environment.

Dr. Peter Golding, University of Texas, El Paso

Professor in the Department of Engineering and Leadership at UTEP.

Dr. Virgilio Ernesto Gonzalez, University of Texas, El Paso

Virgilio Gonzalez, Associate Chair and Clinical Associate Professor of Electrical and Computer Engineering at The University of Texas at El Paso, started his first appointment at UTEP in 2001. He received the UT System Board of Regents Outstanding Teaching Award in 2012. From 1996 to 2001 he was the Technology Planning manager for AT&T-Alestra in Mexico; and before that was the Telecommunications Director for ITESM in Mexico. His research areas are in Communications Networks, Fiber Optics, Wireless Sensors, Process Automation, and Engineering Education.

Mr. Mike Thomas Pitcher, University of Texas, El Paso

Mike Pitcher is the Director of Academic Technologies at the University of Texas at El Paso. He has had experience in learning in both a traditional university program as well as the new online learning model, which he utilizes in his current position consulting with faculty about the design of new learning experiences. His experience in technology and teaching started in 1993 as a student lab technician and has continued to expand and grow over the years, both technically as well as pedagogically. Currently he works in one of the most technically outstanding buildings in the region where he provides support to students, faculty, and staff in implementing technology inside and outside the classroom, researching new engineering education strategies as well as the technologies to support the 21st century classroom (online and face to face). He also has assisted both the campus as well as the local community in developing technology programs that highlight student skills development in ways that engage and attract individuals towards STEAM and STEM fields by showcasing how those skills impact the current project in real-world ways that people can understand and be involved in. As part of a university that is focused on supporting

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the 21st century student demographic he continues to innovate and research on how we can design new methods of learning to educate both our students and communities on how STEM and STEAM make up a large part of that vision and our future.
Abstract

The objective of this research is to demonstrate the performance of a new mechanism to improve the advising of students in a nontraditional college environment, specifically the University of Texas at El Paso (UTEP). Minority serving institutions, commuter campuses and institutions with a high percentage of student transfers are unable to keep a tightly controlled cohort of students progressing through the curriculum. Students usually have varied course loads and different priorities due to family, financial needs or other responsibilities. Therefore, there is a need for an individualized approach to advising. The school’s administration faces challenges scheduling courses and allocating diminishing resources to satisfy student demand. In addition, faculty needs to assess the efficacy of their curriculum in a program, and collecting longitudinal student data is difficult.

A web application system (mobile compatible) using a multi-agent approach has been developed to allow the students (agents) to take more control over their individualized advising. In this context, the student tool becomes an agent, and the school provides the environment with a desirable behavior for the system. This research will identify the school’s administrators as the academic control objective and will be referred to as the "Operator". This paper focuses on the agent system by building a dashboard tool that collects each individual student’s information regarding their progress through the curriculum in a program, and then generates advising recommendations. The agent logic employs principles used in project management tools designed for resource of schedule optimization. The tool helps students optimize their resources to complete their degree sooner. It provides a visualization map of course sequences, customized for each student based on their history of courses completed and then making advising adjustments that will optimize the time to obtain the degree under a constrained set of resources. At the same time, the agent system provides real-time feedback to the department administration. The second tool is the department administration dashboard that consolidates the collected data from the students through several semesters (historical data) plus the predicted effects of the recommended plans. This enables a better resource allocation from the administration and deeper analysis of the curriculum effectiveness. Previous work during year one of the research has presented some insight into the multi-agent approach and the critical path methods. However, the proliferation of mobile devices and Cloud computing enables a larger scale application of the proposed methodology. The results acquired at this point from year one show a very high acceptance of the system by the students. The complete dataset from year one and year two will be discussed extensively in the results section as data from year two is compiled and added to this paper during the Spring 2017 semester, as more students use the system.
Introduction

Students’ time to graduation in college is one of the most important metrics used to evaluate higher education institutions. This is a metric of performance used at a national level. Time to graduation is affected by many factors. Most of these factors are social, economic and planning in nature. There have been attempts to provide incentives to students to encourage them to graduate from college as quickly as possible in order to optimize the use of available resources\(^1\). When compared, some of these incentives have been more effective than others\(^2\). Some students take longer than expected to graduate with a 4-year undergraduate degree.

Specifically, at The University of Texas at El Paso (UTEP) students take longer than the national average\(^3\) to graduate\(^4\). Some of the factors for this delay include: social setting (commuter campus), low-income student population, cohorts not as homogeneously defined as in a residential campus, under 15 credit enrollment, school/work overload, student’s schedule planning, diminishing resources to universities and colleges, and the lack of available data to the students and the department administration. All of these characteristics make the advising process very time consuming and one that is not always tailored to the specific need of the student being advised, but a general one-fits-all process. In some cases the data is available but the amount of time needed to search for it makes it prohibitive to the department administration and/or student. Currently, there is a lack of a readily available and user-friendly system capable of implementing a systematic and repeatable process to analyze data in real time (to optimize resource allocation), and present it accordingly to students and the department administration. The current advising systems at UTEP are based on historical values only. The advising workflow that the department administration uses drives the advising process. Currently the advising process has the following characteristics: a top-down system, centralized, with one-way communication, manual monitoring, and a few customer choices. It has similar characteristics to the early power grid before the smart grid\(^5\). The developed system (iAdvise) is inspired by the smart grid, and the same terminology will be used in this paper. Specifically, in the smart grid the “operator” term is used to refer to the administration of the smart grid. In this study the term operator will refer to the department administrators. In the smart grid terminology, the term “agents” is used to refer to the independent user that uses the power grid. In this study it will refer to the students. Another characteristic of the current advising system is that it has partial information without real-time input from the agents as shown in Figure 1. Due to all of the previously mentioned characteristics, a large gap in communication leaves a lot of room for the optimization of this process.

In order to optimize the advising process in the setting previously defined and keeping in mind a systems approach to this challenge, we are proposing the application of a multi-agent technique that will allow the students to take more control of their individualized advising. This proposed system is similar to the smart grid concept which was chosen due to the positive feedback from the implementation of such distributed control systems\(^5\). In this context, the student tool becomes an agent and the program administrators become operators that provide (with certain flexibility) the environment with a desirable behavior for the agents. The flexibility of the system allows the agents to choose a path to graduation optimizing the agents’ resources. Similar to the Supervisory Control and Data Acquisition (SCADA) model, the operator would provide parameters to maximize the throughput of agents through the system (degree program).
But it is up to the students to provide the proper parameters to the agent to finally choose the load (classes, work, and other activities) that they can handle to make an optimal resource allocation decision. The designed Multi-agent control system provides instant feedback to the agent detailing the most probable outcomes based on the agent selection of classes in combination with common workloads ranging from one hour to forty-hour workweeks.

![CURRENT SYSTEM MODEL (TOP-DOWN CONTROL MECHANISMS)](image)

Figure 1. Current control system used for advising (Top-Down approach)

The smart grid works based on incentives. Similarly, the operator can provide incentives based on the dashboard information coming from the aggregate data of the agents. This approach creates an elastic system, as opposed to a top-down deterministic system. Using the concept of distributed control in real time, the dashboard updates using the agent’s feedback in real time. Having this information channel available, as shown below in Figure 2, enables the operators to do near real-time resource assignment. For example, if the operator sees on the dashboard that 60 students are planning to take the Digital Design 1 class (Code name for the Digital Design 1 class is EE2369) and there is currently only one section scheduled of EE2350 with 30 available seats, then the operator can then make the decision to move another instructor to open another section of EE2350 where it will have a greater impact of moving more agents through the system to graduate faster. Another possible solution that the operator can provide is to move the EE2350 class to a larger classroom that will fit the 60 students. This creates an optimization of available resources taking into consideration the agents’ available resources at that point in time (semester class schedule, time available, money, etc.). The proposed system will simulate a Multi-Agent Control System implemented on an educational setting and potentially this control system can change agent behavior and positively impact degree progression and subsequently graduation rates. A longitudinal analysis is starting at this point to analyze the degree progression of agents starting to use the system, this is the second year that the iAdvise system is being used by the Electrical Engineering department.
In this proposed model the operators and agents receive real-time data from the agents’ choice of schedule and using that information plus historical data from previous semesters they can incentivize the system by accelerating the flow of agents through the system. Agents provide real-time data input to the systems and the operator sees this data. Using this system, the agents obtain access to general historical data in real-time to help plan the load for the short and long term. This historical data is presented to the agent in a user-friendly way. In the current environment agents usually do not look at this historical data to plan their graduation path.

**PROPOSED SYSTEM MODEL**
(DISTRIBUTED CONTROL MECHANISMS)

![Diagram of system model]

Figure 2. Proposed Distributed Control System.

**Materials, Methods and Implementation**

This research specifically focuses on the impact of the “Multi-Agent control system applied to a social setting”. This pilot has been focusing on the Electrical Engineering department student body that represents university demographics, accordingly. This research has measured students’ perceived value of using this system and the results of the perceived value can be seen in Table 1 in the Results section. These results are discussed in the Discussion section. In the implementation phase, students were instructed to start using the system before meeting with their advisors. Given the demographics of the population, content, and subject matter involved, this type of study has not been previously done. This research provides important information for the engineering and engineering education fields due to the demographics projected by the 2010 US Census bureau. This projection by the US Census bureau shows a projected national demographics (2050) trending towards UTEP current
demographics. Based on the effectiveness of this system, it could be added to the engineering institution toolbox to increase STEM success in higher education institutions and later be implemented to other colleges.

The methodology leading to the development of this system started with the analysis and mapping of the systems (degree plan and advising process) currently in place. Mapping the required flow of agents in the current degree plan provided a critical path to a degree plan. For this analysis the critical path was mapped for the classes required to graduate with a BSEE degree. The next step was to create the mathematical model to simulate the iterative nature of the system. The mathematical model is equivalent to a discrete Finite Impulse Response filter (FIR), as shown in Figure 3.

![AGENT VISUAL MODEL](image)

Figure 3. Agent Visual flow model (FIR model).

The BSEE degree plan is being used as a pilot to measure the effectiveness of the distributed Complex Discrete Data Control System. This research started in the summer of 2014 and the infrastructure required has been built, the 2015-2016 year we had over 100 students use the system and for the 2016-2017 we expect that number to grow.

During Phase 1 of the pilot (2014-2015), the operator or advisor view consisted of access to the same reports in a Learning Management System (LMS) system and some MS-Excel forms plus a existing data analytics tool, as shown in Figure 4. The risk assessment tool, currently being used by the school, only provides a “risk” level assessment based exclusively on historical data and does not make any recommendations. Using the iAdvise platform, the student was able to obtain the passing rate of students that have taken those classes during the last 5 years. Using this information, the student was able to plan a balanced number of classes to prevent an overload that could result in a low grade.
An web infrastructure was developed, it was needed to integrate mobile and online environments (iAdvise). These environments (app/online) allow for the search of historical data and provide real-time feedback to the agent in a user-friendly manner. The design and implementation of a database with several tables is designed as the back end of the system. A critical part of the design is the algorithm needed to calculate the load of the agents. This critical path was analyzed using several total quality management (TQM) techniques. Some of these techniques take into account organizational and cultural changes. In this research we used the results from Microsoft Project. Several templates were created using this management tool. These templates represented the Electrical Engineering degree plan shown on the reference. Resources were then allocated representing the number of credits that a student can take and requirements for each class. This algorithm takes into account the following parameters: agents’ class schedule, workload, and class difficulty based on historical data of pass/fail rates. Another important aspect of the algorithm is that it takes into account the “60 Hours Rule” developed by Dr. Mulinazzi. This rule assumes that a person can be productive for 60 hours a week for the length of a semester. This parameter provides a great reference due to the nature of the demographics of this campus.

The operators are benefiting from this system by having access to real-time data. A dashboard has been developed for the operator that shows the number of agents planning to take each class of the curriculum. This optimized the way the operator distributes the resources of the department to maximize the flow of agents through the system. With this data readily available to the operator, the system’s bottlenecks are clearly shown and at the same time a prediction for future demand for the course is realized based on current system saturation levels. The operator is able to quickly see underutilized areas of the system without having to dig for hours looking for that important data. This is a system of systems with an iterative nature. As more iterations are available (one iteration per semester) it will be able to statistically predict a long-term agent data flow with more accuracy.

In this first iteration of the system, data has been gathered, and results on the following fronts are shown in the results sections:

- Initial results on agent performance in iteration 1 (Quantitative Survey on the results of how fast the agents perceive to be moving through the system).
- Agent perception of the system (Qualitative Survey) and Operator perception of the system.

**Research focus on impact of iAdvise on agent’s flow through the system**

The main focus of this research is on the speed of progression towards a degree for the agents. Most of the benefits of the Multi-agent control system in the short term have already been listed. However, one very important benefit is how this system affects graduation rates. The speed at which an agent goes through the system is directly related to the graduation rate. As more and more agents go through the system using optimally available resources, the shorter the time needed to complete a degree. In order for this experiment to be done, a longitudinal analysis is being conducted. This longitudinal analysis began this 2015-2016 school year with the first iteration of students using the iAdvise platform. Results from the first year usage are shown at the end of the results section and the result for the 2016-2017 year will be added towards the end of the Spring 2017.
Figure 4. Advisor existing dashboard based on historical data used during Phase 1 of the pilot.

Research focuses on student perceived value

Another focus of this research is the students’ perceived value of a tool like this. Experiments were conducted to analyze student perceived value of the system. The first of these survey instruments was given to a group of 107 students. Furthermore, for this experiment, a post-attitudinal survey was given to all of the agents using the system after they have used it. This survey was conducted by an independent entity not related to the development team.

Results and Assessment

Results of this study are in an early stage. At this point the results of this system are in an early stage, after a year and one semester of results. However, after the design of the model and using a first implementation on the LMS website and the automated forms, a positive response from agents and operators (students and department administrators) has been obtained. For example, there are fewer cases of students enrolling in courses where they lack the proper prerequisites due to errors.

During Phase I of the implementation, one important benefit surfaced. Using the LMS allowed the department to reallocate resources due to the load reduction on the advisors. The EE department used to have 3 full-time employees devoted to student advising. After the first part of the implementation concluded, only one advisor and two part-time student advisors (MS students acting as undergraduate advisors) were needed. The number of students advised per semester increased using this system. Previously 160 students were advised per semester (Fall 2013). During Fall 2014 the number of advised students increased to 240. Using the current data from this first implementation plus historical data that is available, a benchmark was created before the distributed Complex Discrete Data Control System was implemented.
Bachelor of Science - Electrical and Computer Engineering Degree Plan (checklist)
Catalog: 2014-DRAFT

Full Name:

Ready to enroll or passed ENGL1311? blank
Ready to enroll or passed MATH1411 Calculus? blank
First semester enrolled: blank
How many credits do you plan to take next semester: blank

hours committed to other activities other than school (Family, work, religious, etc.) for the semester selected: 20

Submit

1. Communications (6 credit hours required)
   - ENGL1311 Semester completed blank Final Grade blank Previous Attemps 0
   - ENGL1312 Semester completed blank Final Grade blank Previous Attemps 0

2. Mathematics (3)
   - MATH1411 Semester completed blank Final Grade blank Previous Attemps 0

3. Life and Physical Sciences (6)
   - phys2420 Semester completed blank Final Grade blank Previous Attemps 0
   - phys2421 Semester completed blank Final Grade blank Previous Attemps 0

4. Language, Philosophy, & Culture (3)
   Select one:
   - choose HSM Semester completed blank Final Grade blank Previous Attemps 0

5. Visual and Performing Arts (3)
   Select one:
   - choose ART Semester completed blank Final Grade blank Previous Attemps 0

6. U.S. History (6)
   - hist1301 Semester completed blank Final Grade blank Previous Attemps 0
   - hist1302 Semester completed blank Final Grade blank Previous Attemps 0

7. Political Science (6)
   all 6 SCH must be completed at the same institution
   - pols2310 Semester completed blank Final Grade blank Previous Attemps 0
   - pols2311 Semester completed blank Final Grade blank Previous Attemps 0

8. Social and Behavioral Sciences (3)
   - ciez2326 Semester completed blank Final Grade blank Previous Attemps 0

Figure 5. iAdvise system form for advising
Figure 6. iAdvise system providing real-time feedback to the student on available to enroll classes and expected graduation date based on input to the system.

The results of the pre-attitudinal survey follow (N=107). This survey consisted of 6 questions, one was a Likert type, and two were a multiple choice, two were yes or no and a final open ended question. Table 1 shows the results of question 1.

Question 1 was the following: “Please number your ideal advising system from 1 to 4 (1 being the most preferred and 4 the least preferred).

A. _______ Face to face by appointment  
B. _______ Online system that is mobile compatible  
C. _______ An application that you install on a desktop computer  
D. _______ Other

<table>
<thead>
<tr>
<th>System Type</th>
<th>Most Preferred</th>
<th>Preferred</th>
<th>not Preferred</th>
<th>Least Preferred</th>
</tr>
</thead>
<tbody>
<tr>
<td>Face to Face</td>
<td>78</td>
<td>16</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td>Mobile</td>
<td>21</td>
<td>54</td>
<td>28</td>
<td>1</td>
</tr>
<tr>
<td>Desktop</td>
<td>10</td>
<td>29</td>
<td>48</td>
<td>16</td>
</tr>
<tr>
<td>Other</td>
<td>1</td>
<td>6</td>
<td>10</td>
<td>59</td>
</tr>
</tbody>
</table>

Table 1. Results from question 1
What type of advising would you prefer?

<table>
<thead>
<tr>
<th></th>
<th>Face to face with advisor</th>
<th>Electronic system that is running 24/7</th>
<th>Other</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students</td>
<td>61</td>
<td>46</td>
<td>0</td>
<td>107</td>
</tr>
<tr>
<td>Percentage</td>
<td>57%</td>
<td>43%</td>
<td>0%</td>
<td>100%</td>
</tr>
</tbody>
</table>

Table 2. Shows question 2 and the results of the answers received for question 2

After grouping the answers from questions 1 into two groups: “at least preferred” and “not preferred”, resulting percentages are shown in figure 7.

![Figure 7. Percentage preference of different advising systems](image)

Would you like to have information about previous students success rates of the classes that you plan to take the next semester to balance your load?

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students</td>
<td>103</td>
<td>4</td>
<td>107</td>
</tr>
<tr>
<td>Percentage</td>
<td>96.30%</td>
<td>3.70%</td>
<td>100.00%</td>
</tr>
</tbody>
</table>

Table 3. Shows question 3 and the results of the answers received for question 3
Would you like to know what is the recommended class load as you add classes to your schedule and combine that with a part time job?

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students</td>
<td>105</td>
<td>2</td>
<td>107</td>
</tr>
<tr>
<td>Percentage</td>
<td>98%</td>
<td>2%</td>
<td>100%</td>
</tr>
</tbody>
</table>

Table 4. Shows question 3 and the results of the answers received for question 4

<table>
<thead>
<tr>
<th>What other commitments do you have every week?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>-------</td>
</tr>
<tr>
<td>Students</td>
</tr>
<tr>
<td>Percentage</td>
</tr>
</tbody>
</table>

Table 5. Shows question 5 and the results of the answers received for question 5

In addition to results shown in Table 5 reflecting what other commitments students have every week; an average of Work/Family/Other commitments was calculated with results showing an average of 52.1 hours committed to activities per student. Table 6 shown below displays the students’ preference by grouping the answers from question one into two groups. These two groups being prefer and not prefer.

<table>
<thead>
<tr>
<th>Advising System Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>System Type</td>
</tr>
<tr>
<td>Face 2 Face</td>
</tr>
<tr>
<td>Mobile</td>
</tr>
<tr>
<td>Desktop</td>
</tr>
<tr>
<td>Other</td>
</tr>
</tbody>
</table>

Table 6. Students’ preference grouped by preferred and not preferred from table 1

**Post-iAdvise usage Survey Results**

Survey results for year one of the study, from the students utilizing the system have been captured and are shown below. This last survey was designed to measure two aspects of the iAdvise system. The first aspect measured was if the system was reaching established goals and, if that was the case, how well it was performing at reaching those goals. In other words, was the system functional and what was the performance. The first question focuses on the agent choice of advising system. It is very important to consider the fact that agents have used both systems. This brings more relevance to the question because they are able to compare both systems. Table 7 shows the agents’ responses to this question. As can be seen, use of iAdvise is overwhelmingly preferred over the current system. Statistics on the preference of usage of the iAdvise platform were collected during the Spring 2016 advising season and are shown below.

1. Which would you prefer to use to see classes that you would like to enroll in?

| The iAdvise System | 49 | 92% |
| The Excel file form | 4 | 8% |

Table 7. Results from post development question 1 spring 2016.

According to the literature review, one of the main causes of extended time to graduation is a flawed schedule created by students. Not choosing the right course is one of the worst
scenarios since it creates a non-optimal usage of time and money. Question 2 directly asks students about the ability of iAdvise to prevent them from enrolling in courses that do not count towards their degree. Table 8 clearly indicates that the vast majority of the agents agree on the positive impact that using iAdvise has in preventing them from making less than optimal course choices.

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>No</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Do you believe a system like iAdvise can prevent you from enrolling in classes that do not count towards your degree?</td>
<td>49</td>
<td>4</td>
<td>92%</td>
</tr>
</tbody>
</table>

Table 8. Results from post development question 2 Spring 2016.

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>No</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>3. After using the iAdvise system do you have an idea of your expected graduation date?</td>
<td>45</td>
<td>8</td>
<td>85%</td>
</tr>
</tbody>
</table>

Table 9. Results from post development question 3 Spring 2016.

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>No</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>4. Does seeing your expected graduation date motivate you?</td>
<td>46</td>
<td>7</td>
<td>87%</td>
</tr>
</tbody>
</table>

Table 10. Results from post development question 4 Spring 2016.

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>No</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>5. After using the iAdvise system do you see the actual impact of the relationship between credits enrolled per semester and your graduation</td>
<td>52</td>
<td>1</td>
<td>98%</td>
</tr>
</tbody>
</table>

Table 11. Results from post development question 5 Spring 2016.

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>No</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>6. After using the iAdvise system can you better plan your semester class load in conjunction with your outside school commitments (work and/or family) based on your available time?</td>
<td>46</td>
<td>7</td>
<td>87%</td>
</tr>
</tbody>
</table>

Table 12. Results from post development question 6 Spring 2016.

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>No</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>7. If you keep using the iAdvise system semester after semester, do you think you can graduate on time (4.5 years)?</td>
<td>49</td>
<td>4</td>
<td>92%</td>
</tr>
</tbody>
</table>

Table 13. Results from post development question 7 Spring 2016.
8. Which system would you say is easier to use?

<table>
<thead>
<tr>
<th>System</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>The iAdvise System</td>
<td>44</td>
<td></td>
</tr>
<tr>
<td>The Excel file form</td>
<td>9</td>
<td></td>
</tr>
</tbody>
</table>

Table 14. Results from post development question 8 Spring 2016.

9. Does the iAdvise system help you complete the “Academic Advising Form” faster and easier than the previously established process by your EE

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>3</td>
</tr>
</tbody>
</table>

Table 15. Results from post development question 9 Spring 2016.

10. Does the iAdvise system help you check class pre-requisites and co-requisites faster than with previous methods? (the previous method was using the Excel File editing of “BSEE_2014_v5.xlsx” or the degree plan)?

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>3</td>
</tr>
</tbody>
</table>

Table 16. Results from post development question 10 Spring 2016.

Question 11. What other features would you add to the iAdvise system?

Some of the comments suggested that the iAdvise Multi-agent control system could use more graphics to make it even more appealing to the agents. The automatic check of transcripts was another common suggestion. Finally, it was suggested to develop a link to the UTEP Banner database to be able to automatically provide CRN numbers and specific class times.

Discussion

At this point the research of the Multi-Agent Control System with the application of social modeling has begun and every day more results are becoming available after the first iteration of the online system went live in the 2015-2016 school year. After analyzing results of the attitudinal surveys for the past 6 years it can clearly be seen that the students’ perception of technology and learning change in a positive direction after the proper usage of advanced technology by students. This multi agent control system provides an option to traditional advising methods by providing a custom advising solution taking into consideration external factors affecting the students’ life. Moreover the Multi Agent Control System is on a platform that is very popular (mobile app) among college students making it very appealing to them.

From the results of the survey question shown above in the different tables, it can be seen that the student preference is to have a face-to-face system with an approval rate of 87% among the students. The second preference is to have a mobile application for advising with an approval rate of 70.1%. These results evidence for student approval of the iAdvise system. Another interesting result is the fact that, on average, the students surveyed have 52.1 hours per week committed to school and other activities. This makes an excellent case for the need for the iAdvise system that can be accessed 24/7 for advising without the need for the students to spend time scheduling a meeting for advising in addition to the length of the advising meeting itself.
Even in the event that an appointment with an advisor is needed, the length of this appointment potentially reducing the length of such meeting

**Conclusion**

At this point more and more student data is becoming available since the Multi-Agent Control System is acquiring information from the students. The first cycle of the data collection has begun this 2015-2016 year and the 2016-2017 school year data is about to be added at the end of the Spring 2017. Based on the data acquired from previous years on the partial automation of the advising process, it is clear that the next logical step is to combine the information from the different sources and display them in a more user friendly manner as the iAdvise system is doing it right now. The operators of the system have now a dashboard and they are using it. As for the agents, this proposed Multi agent distributed control system is doing the streamlining of the advising process. At this point the question of “Can a Multi-agent distributed control system be used as an advising system?” can be answered with a clear yes based on the results from the surveys, agents, and operators. Furthermore, the answer to the first secondary question: “Can an advising system modeled after a Multi-agent distributed control system provide more control to the agents over their individualized advising?” The answer again based on the functional results and the qualitative results is YES. The Multi-agent distributed control system provides more information to the agent empowering them to use this new information to better manage their flow across the system. Lastly the answer to the second secondary question “Can an advising system modeled after a Multi-agent distributed control system improve the operator visibility over the advising system?” The answer based on the functional results the answer is YES due to the fact that the Multi-agent control provides more visibility by showing the intended enrollment for the next semester, bottleneck information based on previous class attempts, and total level enrollment. The the Multi agent control system, iAdvise provides an option to traditional advising methods by providing a customized advising solution tailored to each student and taking into consideration external factors affecting the students’ life. Moreover, the Multi agent control system is on a platform that is very popular (mobile app) among college students making it very appealing to them. Most importantly, based on all of the post usage survey results, the iAdvise system proves that a Multi agent distributed control system provides a new way to optimize human and infrastructure resources. The optimization of these resources maximize the flow of agents across the educational system and minimize time loses in an educational setting.

**Future Work**

At this point in time, after examining student data in the system, we can see that the system could be expanded by adding modules to increase the accuracy of the system predictions. A couple of the features of this Multi-Agent Control System that can be added in the future to increase the accuracy of the system are the correlation of prerequisites to forecasting future course Pass/Fail and the analysis of learning outcomes in each course to provide an agent preparedness factor to the algorithm. A longitudinal analysis should also be done as the students’ preference may change in the future, making the iAdvise system more popular than face to face or the opposite. To have outcome based results more data is needed, each semester there is an additional iteration of students using the system, in the near future as we go into the third year of the system in place more outcomes positive or negative can be addressed using this system as it is built to provide that visibility to the operator.
References


