A GRADUATE COURSE COMPARING THE MAJOR TYPES OF URBAN MODELS

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A Graduate Course Comparing the Major Types of Urban Models

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Abstract

We describe our experience teaching an overview course on urban modeling for graduate students at the University of California, Davis. It was decided at the outset that we would let the students run actual calibrated models in this class. This may be the first course where students were exposed to GIS models, as well as to spatial competition (economic) models. We conclude that the active learning format was successful in getting the students to understand the purposes of the various types of models and their limitations.

Motivation

Effective urban planning and infrastructure investment rely on our ability to assess future needs today. Models are one instrument for obtaining projections of what future conditions will be. While models can be useful tools, there are barriers that discourage their use more broadly. One of the earliest criticisms of urban models was that they are too complicated for many people to readily understand (Lee, 1973). This produces the "black box" effect in which decision makers and citizens are left to trust the model outputs without sufficient explanation of how those outputs were generated.

While the use of large-scale urban models has increased in recent years (TMIP, 1998; Wegener, 1994), the primary user of any urban model is most often its creator. This situation may be changing. Evidence of the growing interest in these models is demonstrated by the number of model applications in the United States within the last few years (see Table 1).

These models can suffer from a number of problems, ranging from poor documentation, to complicated or non-existent user interfaces, to closed-code licensing.

Each of these issues presents obstacles to the broader understanding, use, and development not only of these models specifically, but to the field of urban modeling more generally.

Recently, the University of California Transportation Center (UCTC) funded the development of a graduate-level course in urban modeling. The challenge of the course was twofold: first, to present urban modeling to a group of students from diverse backgrounds and levels of mathematical and statistical sophistication, and, second, to do it within the limited time frame of a 4-unit, one-quarter class. The course was developed at the University of California, Davis where there already existed separate courses in Travel Demand Modeling and Discrete Choice Analysis and course overlap was discouraged. Consequently, this course did not focus on model estimation, but rather on a survey of existing, operational urban models that have been implemented within the United States. The focus of the course was on modeling frameworks and the benefits and drawbacks of different types of model structure and levels of complexity.

This course is the first of its kind that the authors are aware of. There are at least three other courses that cover urban modeling. For instance, Paul Waddell teaches a course on "Urban Simulation" at the University of Washington, but it appeared from the online syllabus that this course focuses more on model building and estimation and emphasizes a single model, UrbanSim, rather than a diverse selection of modeling frameworks for different uses. The University of Florida also teaches a course that focuses on a single model, the Urban Land Use Allocation Model (ULAM). Both of these courses have a full syllabus or outline available on the internet and were reviewed in the development stage of our course (Web addresses—available as of 7/17/03:

http://faculty.washington.edu/pwaddell/Models/Urban_Models_Syllabus.htm and http://www.ulam.org/Training.html respectively). Another similar course is taught at the University of Pennsylvania but only a short course description was available online. The review of other courses was limited to material available via the Internet due to the abbreviated course preparation period (funding was approved in January and the course began in April).

The structure of this course and methods for presenting the material are the focus of this paper and should be of interest to planners interested in presenting similar material to non-modelers (citizens and elected officials), as well as to planning instructors at the university level.

Active Learning

At the outset, it was decided that elements of active learning would be the foundation for this class. Wright (1993) states that support for active learning depends on two basic assumptions: (1) that learning is by nature an active endeavor, and (2) that different people learn in different ways. (University of Indiana, Bloomington Web site: www.iub.edu/~teaching).

"[S]tudents learn best when applying subject matter—in other words, learning by doing—and, second, ... teachers who rely exclusively on any one instructional approach often fail to get through to significant numbers of students. As a result, both teachers and students end up dissatisfied. By increasing active learning strategies in our teaching, we increase the odds that students will leave our classrooms with more than a notebook full of “facts.” Research does demonstrate that when we use information (for example, rehearse it or solve problems with it), we are more likely to retain it (Bransford, 1979).

And when we involve students in activities that lead them to discuss, question, clarify, and write about course content, we not only foster better retention of subject matter but help expand students' thinking abilities as well" (Myers and Jones, 1993, pp. xi-xii, in www.iub.edu/~teaching).

"Try to include activities that allow students to learn in a variety of modes. The more active involvement students have in the learning process (through discussions, question and answer sessions, group projects, problem sets, presentations, etc.), the more information they will retain and the more enjoyable they will find their learning experience in your course. Using an interactive teaching style may result in the following benefits for students:

- students become active rather than passive participants in the learning process
- students retain information longer
- interactive techniques are democratic processes and thereby give students experience in collaborating and cooperating with others
- problem-solving and critical-thinking skills are enhanced in discussion settings
- some students may learn better in a group situation
- self-esteem is enhanced by class participation
- students are given the opportunity to clarify their beliefs and values
- student motivation for future learning is increased" (www.iub.edu/~teaching)

Background

In previous work, Johnston has designed and applied a simple GIS-based urban growth model, UPlan, in a series of projects (Johnston et al., 2003). He has also applied the TRANUS and MEPLAN spatial competition models in the Sacramento, California region (Johnston and de la Barra, 2000; Rodier, et al., 2002; and Hunt et al., 2002). The latter model, in various incarnations, has been calibrated by Doug Hunt and John Abraham, at the University of Calgary, for this academic work.

The Sacramento Area Council of Governments (SACOG), with whom this work has been coordinated, has recently adopted MEPLAN for use in transportation planning, along with another GIS-based model, PLACES, to be used in scenario-generation exercises in the community. With this experience using both GIS and spatial economic models, and with the backing of a UCTC grant, the decision was made to develop and teach a graduate class. This course took a different approach than the past classes on this subject taught at other universities by presenting an overview course that included: Scenario-generation software (PLACES), simple urban models (UPlan), and complex, spatial economic urban models (MEPLAN). In addition to being fairly representative, these models were selected based on two other criteria. First, they were readily available, “off the shelf” packages and second, they had local examples of application, which, among other benefits, served to enhance student interest.

Basic Course Design

The course was designed in the Winter of 2003, for offering in the Spring. The fundamental decision was to offer a broad course that covered what the authors determined to be the three basic types of models, rather than focus only on the advanced types of economic models, such as UrbanSim (Waddell, 2002) and PECAS (Hunt, 2002). Both of these models were coming into use in 2002, but working versions of these models with data sets were not available during the course preparation period. It was also decided that the overview format would be useful to students, who would gain some perspective on the various kinds of models and their appropriate uses. The course contained readings on UrbanSim and PECAS, but did not run these in the class.

The second fundamental decision was that the students would gain first-hand experience with models by running the full models in the lab portion of the class. This decision to provide for active learning entailed a lot of work for the instructors, in course set up, as well as for the students. The time and effort required by the students to learn, run, and interpret these models did not leave time for the students to estimate a location choice submodel, a typical assignment in urban modeling classes. It was decided that having them estimate a location choice model was not as important to this group of students as having them run the three basic types of models in an applied format.

The course met two times per week, for two hours each time. Lectures predominated in the early weeks, while labs took over in the later weeks. The University of California, Davis runs on the 10-week quarter system, which discourages major term projects. The course did, however, have a significant Final Paper that required the students to use MEPLAN, the most complex of the models covered by this course, to test a variety of policy alternatives for the Sacramento Region.

Specific Course Elements

Table 2 presents the basic skills deemed necessary for students to be able to utilize the types of urban models covered in this course. Due to the time constraints of the course, many of the skills were set as pre-requisites. The major points covered in the lecture portion of the course included: urban economics, land use planning and zoning, modeling structures (for each model), and model evaluation. Each of these will be explained in greater detail below. The lab portion of the course was dedicated to learning and running the models and using them to evaluate land use and transport policies.

[Insert Table 2 about here]

Basic Urban Economics

Before the models could be presented, background needed to be provided on Urban Economics theory and the early models of the '50s and '60s that dealt with spatial competition. Three Urban Economics texts were considered for this portion of the course: Urban Economics (O'Sullivan, 2003), Urban Economics (Mills and Hamilton, 1994), and Modeling in Urban and Regional Economics (Anas, 1987). Upon review of each text it was concluded that the O'Sullivan text would be used. This text was chosen based upon its ability to convey concepts, rather than explicit mathematical relationships, and ease of understanding. A prerequisite for the course was intermediate microeconomics, so that all students could understand the basic urban economics concepts. Urban economics is not offered at UC Davis and could therefore not be a pre-requisite for the course. Week One consisted of a lecture, Overview of Urban Models, by Johnston and one on Central Place Theory and Economic Base Theory, by Clay. The students read the relevant chapters in O'Sullivan covering the work of von Thunen, Alonso, Wingo, and Lowry.

In Week Two, student teams led discussions on Housing Markets, Transportation Economics, and Rents. The intent was to get them to do the readings and learn the concepts by teaching them. The presentations were primarily descriptive, without much analysis or discussion from the class. Clay gave a lecture on Random Utility Choice Models, as an introduction to spatial economics models. There were no assignments on the urban economics materials and the class only spent two weeks on them. We were unable to find software with graphs with which to run small problems based on the above concepts. The students were given a lengthy handout, with a detailed list of economic behaviors that urban models should represent.

The GIS Models

In Week Three, the students read Wegener (1994) and Simmonds (1995), both good overviews of urban economic models, to reinforce the lecture in Week One that reviewed urban models broadly, including GIS models. Johnston lectured on UPlan and demonstrated it in the lab. The students read Johnston et al. (2003) describing this model. UPlan was demonstrated first, as it is the simplest model in the course. It runs in ArcView3.2, the most commonly used GIS software for governments in the U.S., and allocates land uses based on user-set rules. The students ran UPlan on one county in the Sacramento region (Placer Co.) that has severe conflicts among urban development, farming, and habitat protection, and designed and evaluated two land use scenarios for their impacts on farming and habitat values. The students saved their maps and written papers in folders on the lab computers. This assigment went well, with the software running correctly and the students understanding the model's capabilities and limitations fairly well.

In Week Four, the PLACES land use and transportation accounting tool was demonstrated. This is a fairly complex GIS tool intended for scenario generation and evaluation. PLACES development was supported by the USEPA. It also runs in ArcView3.2. For scenario generation the user selects from a list of land use types and clicks them onto polygons (parcels, or planning areas in a county). This links the land use types table to the polygon table, a basic ArcView function. The benefit of this tool is that it can run in real time, returning results within a couple of minutes. One can also mark a group of polygons by drawing a rectangle with the mouse and so large areas of land uses can be simultaneously changed.

Two versions of PLACES exist, a 1-year-old PC version developed by consultants for use in the San Francisco region, and the new Web version that had just been developed by the California Energy Commission. Both are open-code public software. The former was selected, as it was more readily available with a good data set. It was obtained from Parsons-Brinckerhoff, populated with data for Alameda County, California. The students did get to use the online version in the lab. However, the PC version was used for all assignments. The online version suffered from two deficiencies that made it more difficult to work with. First, there was no manual for the online version and second, access to this version was limited. At the time the course was being offered, SACOG was in the process of using the PLACES planning tool in their 2003 visioning and public outreach meetings. As a result, access to this version was tightly controlled. Only SACOG had a working version of PLACES on the Web, as they were the first test case for the Energy Commission development project. We received permission from SACOG to use one of their county setups, for Sutter County (in the Sacramento region). The polygons were parcel boundaries, which made for a complex map, but one with spatial detail. The county includes one small city and lots of rural farmlands and Sierra foothill lands.

Both the PC version and the Web version of PLACES were demonstrated in class and some time was spent discussing how the software works in ArcView. The class discussed the evaluation function in PLACES, which is the main reason MPOs have used it for visioning. (The Metropolitan Transportation Commission in the San Francisco Bay Area used PLACES in 2002 and 2003.) The students were generally satisfied with most of the evaluation indicators (described in the appendix of the manual for the PC version).

Comment [c1]: Bob, I like what you are saying here about the USEPA but we ought to try and re-word it. It sounds a little awkward as is.

The assignment was to play around with scenarios for Alameda County, using the PC version of the model, and then to describe PLACES and evaluate it, in terms of how well it represents basic urban economics concepts in practice. The students generally thought the interface was complex and unclear but acceptable, and that the model was an easy way to describe land use scenarios and to evaluate them. They did not think the vehicle miles of travel (VMT) measures were accurate enough to use, since they were based on local land use density, not related to travel. The students also did not like the fact that the user can just plug in any development (any number of buildings, of any size or density, and for any use) anywhere, without considering the balance between jobs and housing, applicable local zoning, or other factors.

Most students favored using UPlan, instead of PLACES, as UPlan allows changing land uses not by polygon but by policy, such as changing the densities for each land use category, or changing the general plan for each city or county. They favored this approach as being more systematic and requiring the consideration of countywide tradeoffs and needs in setting policies. All of the students in this class were graduate students in a transportation program. Most, but not all, had B.S. degrees in civil engineering. Students in urban design and landscape architecture may evaluate UPlan and PLACES differently.

The MEPLAN Model

In Week Five, the students read Hunt and Simmonds (1993) for a basic description of MEPLAN. They also read Abraham and Hunt (1999) for a description of the Sacramento MEPLAN application. The lecture was a description of the Sacramento MEPLAN model, which is quite complex. The lectures described the version that was being used in the class, which represents floorspace production and consumption explicitly (SacMeplan2).

In the lab session, the students were given a run-through of the model, showing them the inputs that they could change and the most important outputs to evaluate. All model runs were to be to the year 2020 (a 30-year projection, since this model has a 1990 base year). MEPLAN is written in FORTRAN and is operated using DOS commands. It has a modular architecture that calls and writes to numerous data files as it steps through time. New scenarios or policy tests require new files. This can build up to an enormous amount—over 3,500 files in the version used for this course. Each data file must be manipulated manually, one character at a time. In addition, the user must keep track of control totals and any other requirements, including other files that access that character space. The complexity of the files, file structure, and ease of erring while manually entering data and changing files and folders were obstacles that needed to be overcome prior to the introduction of this model in a classroom setting. The grant from UCTC was used to fund the creation of a graphical user interface (GUI) for the MEPLAN model.

With this $8,000 grant, a programmer was hired to develop a GUI using Access. MEPLAN requires a large set of data files that are operated on by DOS commands set by the user, making it quite easy to get lost in the operations. There is a basic MEPLAN manual, which fails to document the operation of the model; it only details the files and file structures, but none for this application specifically. It was decided to make only a few inputs available to the students, to simplify their efforts. The goal was for them to be able to manipulate both the travel market and the land market represented in MEPLAN. The students were allowed access to the global variable for out-of-pocket costs for auto travel (default is $0.15/mi.). This could represent higher auto costs (including a change in gasoline taxes), or lower relative transit costs. We also let them select the regional transportation network, but limited these to: No Build, New HOV Lanes (on all freeways), and Transit (which added new light rail lines and feeder buses and reduced headways on the whole system). These, and other, networks had been prepared for earlier research by Johnston and others, using this model. Network preparation for this model was time-consuming and so having them already done was one reason to use this model. Network editing for travel models and for some urban models has only recently become fairly easy to do, using GIS-based methods.

Two inputs for the land market were also selected. First, the students were allowed to change the acres available for development in the 53 internal zones in the (four-county) model. In each zone, they were allowed to interchange available, vacant land among four land use types: Open space (not developable), Industrially designated land (which permitted all developed land use types), Medium-density residential, and Low-Density residential. Most of these lands in the region have Open Space or Medium- and Low-Density Residential zoning designations so this subset of land uses made the majority of undeveloped land available to manipulate in most zones. The Access GUI was designed to keep the zonal acreage totals the same (necessary for the model to run properly). The students could simulate NIMBYism by restricting land availability in mostly- or partly-developed zones and could simulate urban growth boundaries by restricting land availability in outer zones.

The second input parameter affecting the land market was the constant term in the submodel for zonal developer choice to change from one land use type to another. We made available all of these constants for changing from Vacant to Vacant and from Vacant to each of the developed land uses (Industrial, High-Density Commercial, Low-Density Commercial, High-Density Residential, Medium-Density Residential, and Low-Density Residential), or from any developed land use to any other developed land use. The purpose of changing this parameter was to simulate hot markets for certain land uses (new or redeveloped) in certain zones, or to simulate real estate investment biases, such as for low-density housing or for offices.

Several (of the many) model outputs were made readily available in the GUI, including: regionwide VMT (which would also represent mobile emissions and energy use), mode shares, average trip speed, number of trips, population by zone, and employees by type by zone. The user interface made it possible for students to compare all years within the same policy run or the same year across two different policy runs.

Clay was in charge of meeting with the programmer to get the GUI done, during the quarter before the class. This involved about three meetings with both of us and ten with only Clay and the programmer, over a two-month period. The GUI was done a month before the class started and was tested with many combinations of inputs and mis-keying in every way the instructors could devise. After two brief debugging sessions with the programmer, it was believed that the GUI was clean.

In Week Six, the MEPLAN tutorial was assigned, for additional help with understanding MEPLAN, and Rodier et al. (2002) for a policy analysis completed earlier using this Sacramento MEPLAN model. Johnston lectured on using MEPLAN for policy analysis and its benefits and limitations. The lab session focused on using the GUI for MEPLAN. There was confusion about when to “Reset” the model inputs and parameters back to the Base Case so a set of instructions was produced for that and the GUI modified to include instructions on the opening dialog box regarding this issue. The assignment for this week was to describe MEPLAN and identify which economics concepts it represents and how it does this.

In Week Seven, the students read Hunt et al. (2001) for an overview of urban models and a recommended U.S. model improvement program. Johnston lectured on the SACOG model improvement program, which features improved travel models and urban models, going to an improved MEPLAN in 2003 and a first PECAS model in late 2004.

The lab was supposed to be on the use of all models for policy analysis, with a broad discussion of all of the models and their respective roles in MPO planning. However, the session was spent working with MEPLAN again, as the next midterm assignment was to design and run two or more scenarios and to evaluate them. Students were getting reasonable results for some scenarios and unreasonable results for others, with no apparent pattern to the mistaken results. The students appeared to be using the GUI correctly.

In Week Eight, the MEPLAN policy analysis papers were graded and the results seemed to be a mixed bag of reasonable and unreasonable outputs. Johnston and others had run the model many times for previously published research, not using the GUI, and

Clay and Johnston had run the model with the GUI many times, and so had a good idea of how various inputs affected outputs. At this time, Clay, working overtime with the students in the lab, discovered that the GUI was not reading the right files, when getting certain inputs. This explained the pattern of mistaken outputs, as this problem only occurred when you overwrote a previous policy set. So, the students did a heroic job of explaining wrong outputs in some of the papers, for some of the scenarios and were congratulated for their determination. Clay and the programmer corrected this last set of bugs and the GUI then ran properly.

Beyond MEPLAN

For Week Eight, the class went beyond MEPLAN to a discussion of PECAS, which has a superior measure of producer surplus and many other improvements (similar to those in UrbanSim) and should be more useful for policy analysis. The innovations in the UrbanSim modeling framework, including: microsimulation of households, small grid cells, development time lags, and an explicit floorspace developer were presented and discussed, as well as the ability of UrbanSim and PECAS to be linked to the next generation of travel models (tour-based and microsimulation). The students were not assigned the recent technical papers by Hunt and Abraham on PECAS-type modeling or the technical papers on UrbanSim by Waddell and others. Discussions were kept general and focused on model frameworks and practical applications. The students were assigned the PECAS overview talk by Hunt (http://www.odot.state.or.us/tddtpau/3symposium.htmt) and a paper on using GIS and economic models together at SACOG (Johnston and Garry, 2003).

An important linkage covered in this course was that of combining the visual mapping superiority of GIS models with the computational powers of the more sophisticated market-based, spatial competition models. Using GIS models as preprocessors and postprocessors to models like MEPLAN has several advantages. First, it allows for better presentation of outputs, more disaggregate analysis (parcels rather than zones or large grid cells), and better assessment of environmental impacts such as the development of sensitive areas. As a preprocessor, the GIS models could be used (and have been used in the Sacramento area) to input general plan designations, zoning, built land, and land availability for each MEPLAN zone.

The paper for this week was on MPOs using PECAS and GIS models for policy analysis and what important policy outputs would be represented and which ones would not. Meanwhile, the students started working on the Final Paper, which was to perform a more complex policy comparison using MEPLAN with the now-fixed GUI.

In Week Nine, Clay lectured on part of his dissertation research proposal, which is to estimate a probabilistic or logit model of large development projects on the urban edge. MEPLAN, PECAS, and UrbanSim all simulate development of floorspace in small increments in each zone or cell. This type of modeling misses those lumpy events where powerful developers get rezonings of agricultural lands for large projects on the urban edge. These large projects then affect subsequent development patterns. Johnston lectured on pathways for MPO development of travel models, separate land use models, and eventually urban models, as applied to small, medium, and large MPOs in the U.S. This concept is based on Hunt et al. (2001).

Week Ten, was intended for a discussion of equity issues in planning and in modeling, but the class decided to use the time working on the Final Papers. In the final paper, they were to identify unique scenarios that represented various policy issues with local regulators, or travel or land markets. Several policy scenarios were suggested, such as NIMBYism in developed zones, urban growth boundaries (no growth in Open Space zones), oil wars raising auto costs, and different land use and transit combinations as types of smart growth.

The Final Papers were all quite detailed, with innovative schemes of scenarios investigated. All students delved into the outputs in great detail and this time they made sense. Some performed parametric analyses by varying the inputs and parameters systematically. Some examined NIMBY and urban growth boundary assumptions, in combination with various networks. One student developed a Garin-Lowry model, based on employment data in zip codes, for the Hartford, CN region.

Discussion

The ability of urban models to analyze policy alternatives is growing. As these models have improved, their use has expanded. While the models used in this course may change or other models may be selected by other instructors, the overall course structure presented here should be useful. As the use of urban models becomes more widespread the need for such courses will grow. This course structure could also be utilized for professional development by agencies adopting an urban model.

Overall, the broad course topics and focus on applied modeling were a success. Within a relatively short time period students were able to learn the basics of what drives urban models, the importance of the overall modeling framework and its role in answering particular questions or testing specific policies, and how to use them via first-hand experience running three models for testing a variety of policy issues. As the course progressed from simple models to the more complex models the students were able to first, understand the necessity for the more complex models and second, gain an appreciation of the difficulties involved in using them.

Placing the model in the hands of students created the need for the GUI to check each input and parameter change to ensure that it was within allowable limits. The GUI also allows for quick and easy side-by-side comparisons of outputs generated by different policy scenarios. Many model runs are necessary, in order to understand the model, and to explore all policy combinations for desired effects. Many counterintuitive effects occur, that lead to the users learning about urban economic behaviors, in general, and about local problems with land uses and transportation systems.

The development and use the GUI for the Sacramento MEPLAN model proved to be successful, but it was a close call with the last-minute debugging. Overall, this effort was worth it, as the students' Final Papers were rich with groups of scenarios that were designed to test various economic and political concepts. They certainly learned that full urban models are complex to calibrate (from the readings and lectures), and to operate and interpret the results (from their direct experiences).

It is useful to compare this experience with those of instructors who teach travel modeling in U.S. universities. Generally, the instructors have the students estimate logit mode choice models from cleaned-up regional household travel survey datasets. The rest of the MPO's model set is explained, but seldom do students have to actually run the model systems software to get results for regional policy scenarios. This is probably because most systems software is proprietary and the instructor has to pay a fee each year for a site license with several seats. Also, the full model set requires a considerable effort to populate with datasets and to get running. The MPO would likely have to assist, especially if the instructor wanted to get emissions projections, too. Some instructors use simple systems software, such as QRS or others, but these are generally not used on real metropolitan datasets. So, the challenge for this class was not much different from that for instructors of travel modeling courses. Even though travel models are much simpler that urban models, they are seldom used in their entirety in courses.

For instructors without ready access to previously calibrated models this course structure is daunting and perhaps infeasible. With some restructuring, however, elements of this course could be used in a descriptive course on modeling frameworks. The emphasis would shift from running and evaluating operational models to conceptually comparing the frameworks and the theoretical underpinnings of each framework. Students could be asked to develop simple models of their own using spreadsheet operations and readily available census data. Both Lowry and Alonso type models could be created this way and several texts exist that could help step the students through the process. For example, *Modeling the World in a Spreadsheet* (Cartwright, 1993), and *Operational Urban Models* (Foot, 1981), as well as the opening chapters of *Integrated Land Use and Transport Modeling* (de la Barra, 1989) could all be used as the basis for such an exercise. The other readings presented here should still be of interest in this type of course. This descriptive course would provide a solid foundation for students interested in this subject. The complexity of the subject matter for this course also makes it scaleable. While the course presented here was prepared for Ph.D. students a less rigorous version could be created for other audiences. UPlan and Places are free and can be gotten with datasets from their authors. UrbanSim can be downloaded with data for Eugene-Springfield, Oregon. PECAS for Oregon State and for the Sacramento region will be downloadable in late 2004.

One of the drawbacks of this experience was that some of the students were not in command of the basic urban economics concepts in the final weeks of the course. It was concluded that the course should have devoted three weeks to this topic, rather than two. Also, a written assignment on this material should have been included. A basic understanding of urban economics is fundamental to the students' understanding of how urban models are structured and the behaviors being represented.

Of course, the biggest judgment is whether this overview format was successful. The comparative organization and active learning nature of the class got students involved and debating the roles of these models and so seemed successful. The students became quite involved in debating the policy analysis abilities of the models and their costs of learning and application. The students also initiated discussions of the uncertainties of the models and their likely biases and effects on decisionmakers, both citizens and lay elected officials. Finally, they also were quite interested in determining which models would be useful for exactly which roles in agency planning processes: broad, real-time scenario generation in charrettes, quick agency staff-level generation and testing of alternatives, and final detailed evaluation of alternative transportation and land use policies.

In the future, there will likely be fewer jobs estimating location choice and other submodels, than there will be jobs running these various kinds of urban models. Given this, the overview approach was useful for these M.S. and Ph.D. students.

Comments Regarding the Success of Active Learning

Components of active learning were the foundation of this course. Students gave brief presentations on urban economics concepts in one class. This was not enough experience for them, as they did not retain the flood of concepts learned in this two-week period. As mentioned above, if the course were taught again, the section covering urban economics would be stretched out by a week and some written exercises would be added, so the students could reinforce the concepts by applying them in small problem sets.

Computer exercises were sought that would allow the students to apply the most important concepts, but this search was unsuccessful. An attempt was made to reinforce the urban theory ideas with a handout for the lab that listed the microeconomic behaviors (derived from urban economics) that urban models should represent, but it was not useful. Perhaps they should have been asked to refer explicitly to this handout in their papers and to discuss which behaviors each model includes.

The lab part of the course went well, with the students learning how the three urban models function, their strengths, and their weaknesses. Detailed discussions were provided in the class sessions about the models and their appropriate uses. Comparing the models clearly activated the students and led to debates, as they had performed different tests with them and so had differing experiences and opinions. This part of the course was edifying. The lab also permitted the students to learn in an alternative mode to the typical written assigment. These students were primarily from engineering backgrounds and thrived on the trial-and-error mode of playing with computer models.

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Table 1: Selected recent implementations of urban economic models in the United States

Models	Regions
UrbanSim	Eugene, Oregon; Honolulu, Hawaii; Salt Lake City, Utah; and Seattle, Washington.
PECAS	State of Oregon; State of Ohio; and Sacramento, California
TRANUS	Sacramento, California; and the State of Oregon
MEPLAN	Sacramento, California

Table 2: Basic skills required for urban modeling and how they were addressed in this course.

Basic Skill	Skill Development
Basic computer operating skills: windows, spreadsheets, data files, etc.	Pre-requisite
Intermediate micro-economics	Pre-requisite
Introduction to Travel Demand Modeling	Pre-requisite
Basic knowledge of ArcView GIS	Many students already had a working knowledge of this software; some time was devoted to this in the initial lab assignments
Basics of urban land use planning	Lectures, readings, and assignments
Basic knowledge of Discrete Choice modeling	Strongly recommended but not required prior to the course; a two-hour lecture was provided to help students learn to the basics of these models
Modeling frameworks	Presented in lectures and demonstrated in the modeling exercises
Urban Economics	Presented in lectures and demonstrated in the modeling exercises
Model evaluation	Lectures