

# ADAPTIVE LEARNING INSTRUMENTS

Temenoujka Fuller\* and Galina Krumova\*\*

\*Central Arizona College, USA, \*\*University of Rousse, Bulgaria

**Abstract:** *This paper presents the structure and dynamics of the learning process for a group of 51 community college students. A time series data about students learning is collected in a specialized learning center. Students' learning preferences are measured with a learning orientation survey. The fine structure and dynamics of students' learning preferences are presented as a 3D map. On the basis of this map, patterns of behavior are identified and used to inform the development of adaptive learning instruments.*

**Key words:** *Learning Theory, Synergy, Assessment Instruments, Need Analysis, Learning Demand, Learning Orientation*

In the traditional educational research, students' learning needs are usually identified by pre/post tests. However, for any group of students, the learning needs are not a frozen homogeneous state; they have a complex structure which varies from student to student and with the time. The fine structure of students' learning needs is considered in this paper. Student learning is constantly changing with the time during the semester. Simultaneous consideration of the students' personalities and learning behavior are the key to successful application of research-based data into the process of course development. The "geography" of students' independent learning for the case of cognitively homogeneous small group of 51 community college students is presented in this paper as a 3D map.

Two concepts are used in the study: the concept of students' learning demand [7, 3] and the concept of students' learning orientations [8].

The concept of students' learning demand has different interpretations for a course or fine sequencing of material by the instructor in a traditional classroom [7] and for learning demand related to co-curricular services [3]. The learning demand, as it is defined in this study, is about students' free and independent learning outside of the classroom. Students' learning is a multi-component process which includes students' personality, students' motivation and desire to utilize the existing learning services, teaching methods and assessment instruments. This paper presents students learning as it depends on the distribution of students' personality and learning services. For each set of learning services, the distribution of day of visits versus time invested by the learners in a learning center will provide objective measure of the learning demand. The time and day of students' visits are observable and measurable information on the type of learning support which students recognize as important for them. The two dimensional time-dependence (day and duration) of student learning behavior with respect to existing learning services of a community college is used as a measure of the learning demand.

The second concept of the study is the concept of students' learning orientations. This concept is used to reveal how student' feelings and action toward learning services reflect the group's learning behavior. According to Martinez [8], the key question to students' feelings and action about learning is: "How do we provide instruction and environments that match individuals' intent to learn differently, improve learning ability, and continually foster increasing expertise and satisfactory learning relationships?" The balance between what students consider important for their learning and what the instructor considers important for them depends on "the degree to which students feel that their teachers provide a facilitate atmosphere for learning..." [10]. Therefore, the assessment of students' Learning Orientations

(Copyright © 1997-2001, Margaret Martinez) is used to identify students' inborn or trained learning feelings and learning actions [5]. There are five major categories of students' learning orientations [8]: transforming, high performing, low performing, conforming, and resistant. Transforming students are independent learners, performing students are semi-dependent, and conforming students need a step-by-step guidance. The study showed that the transition between the categories is smooth and students within each category may have different scores about their learning orientation.

The next goal of this study is to develop a research-based methodology for selection of learning supplements online that will direct the learning process of a group of students. The research about adaptive learning instruments online requires measurements on the learning demand independent of the classroom instruction. Assessment instruments online have cognitive and learning purposes. Assessment instruments used to direct students' learning are considered and briefly discussed in the light of results of the study. In the future, adaptive learning instruments and observations on the learning behavior of the system will allow fine online orchestration of the harmony between learning challenges (assessments) and students' skills. According to Massimini and Carli [9], students' feelings about learning process depend on the ratio of their skills and the challenges of the curriculum.

Using time series analysis [2] of students learning, this paper describes and visualizes students' non-supervised learning behavior which is close to the learning online. A visual map of students' personality profile versus the use of learning services for the first 7 weeks of the semester is used to forecast the learning needs for the rest of the semester, and to guide the adaptation of curriculum to students' learning process. Some experiments with learning environments designed to provide positive experiences and different opportunities for diverse learning population observed in this study are described and discussed in the light of results of the study combined with related research [1, 9].

**Population:** The target population consists of adult students enrolled in developmental classes in a community college. All students, involved in the study, are low achieving on standardized placement tests, therefore the cognitive characteristics of the group are not taken into consideration. The personality profile and learning demand are studied with 51 community college students. The same 51 students are observed in a learning center for the first seven weeks of the spring semester 2003.

Knowledge of learning differences between community college students' and students enrolled in undergraduate classes in the university is used as a guide for decision-making in selecting assessment instruments for the undergraduate university students in the University of Rousse, Bulgaria.

**Method:** Time series data [2] include 50 days, 15 hours a day observations of the time invested by the students in a learning center. Weekends are not included in the study.

The sampling procedure was convenient but blind. The participants had no knowledge that they participated in a larger study on students' learning demand. Next, all students - those selected to participate in the study and those who were not selected to participate in the study, had equal opportunity to use learning services. The learning center provided tutoring and other learning services with the open-door policy for all visitors; each student, enrolled in developmental classes had equal right to visit the center for assistance by tutors or for co-curricular learning services. Therefore, all combinations of visits were possible. This was a unique opportunity to collect information of random occurring sub-samples of the group of 51 students every day.

Time data collection of students' visits was administered by the front desk check-in and check-out registration. The data were used to trace the date and duration of each individual visit. The visits of all individuals from the sample were traced and recorded every day from

Monday to Friday from 7:30 a.m. to 10:00 p.m., and Saturday from noon to 6:00 p.m. The day and duration of students' visits were used as independent and dependent variables (**Table 1**).

The distribution of students' learning preferences is measured by the Learning Orientations Questionnaire (Copyright © 1997-2001, M. Martinez). The best sequencing for each student [8] depends on student's learning orientations.

The series-time data collected in the learning center were plotted together with the data on students' learning preferences and used to visualize the learning behavior by a contour map. The program "Surfer" (Golden Graphics Software) was used to map the 3D distribution of time versus learning preferences.

The variables of the study are presented in **Table 1**. Two independent variables and one dependent variable are used for visualization of students' choice to utilize learning services during the first 7 weeks of the semester [3].

**Table 1: Dependent and independent variables used in the study**

<b>Variables Type</b>	<b>Variable</b>	<b>Symbols</b>	<b>Axes</b>	<b>Data source</b>
<b>Independent Variable</b>	Days of visits	$t$ day of visit	$X = t$	Check-In Database of a Cooperative Learning Center
<b>Independent Variable</b>	Students' score deviations from the mean on Learning Orientation Survey	$y$ individual score $\bar{y}$ average score for the group	$Y = y - \bar{y}$	Learning Orientation Questionnaire (by Courtesy of Dr. Martinez [8])
<b>Dependent Variable</b>	The time of students visits	$\Delta t = t_2 - t_1$	$Z = \Delta t$	Front Desk Database

**Results:** Need analysis assess through time data collection and visualization was successfully used in the study to inform the design of instruction. The learning time series analysis should be an ongoing procedure for online classes aimed to assess and forecast patterns of learning behavior. Having the forecast, the developer of instruction could select the right method for building learning environments adaptive to students learning needs.

The distribution of time, invested by the students during the first seven weeks of the semester, was used as a time series data [2]. Learning time, invested by the students to study in a learning center, depended on curricular and teaching methods. The study can not be generalized outside of the selected students; however, the method for forecasting students' learning behavior could be used for any group of students. The data on students' free visits to the learning center captured day after day was a manifestation of students' free will to utilize assistance outside of the classroom.

The Learning Orientation Questionnaire developed by Martinez [8] showed that the

majority of the students were performing or practical. Performing students prefer manageable well structured tasks, with enough time for completing the tasks without stress. Transforming students wanted more global and challenging tasks. The survey measured only two out of 51 cases of transforming or global learners who could learn independently. Conforming students preferred small challenges, fine sequencing of the material and constant guidance. Knowing the exact distribution of students' learning orientations is important for sequencing the material online, which is something that good teachers do intuitively. In short term, students follow the requirements of the instructor and their learning needs remain hidden. To observe students' learning needs as they depend on individual learning orientations, educators need long term assessment instruments.

The summary of the raw data about students' learning orientation is presented in the first column of **Table 2**. Column 2 presents the rank of students' learning orientations. Columns 3 and 4 present the distribution of students with different learning orientations measured in the study.

**Table 2: Results of learning orientation survey conducted with fifty-one community college students (Copyright © 1997-2001, M. Martinez)**

Scores	Rank	Frequency	Percent
7 - 5.6	Transforming	2	4%
5.5 - 5.01	Hi Performing	16	31%
5.0 - 4.51	Lo Performing	15	29%
4.5 - 4.01	Hi Conforming	10	20%
4.0 - 3.51	Lo Conforming	8	16%
3.5 - 0	Resistant	0	0%
Average: 4.7		Total: 51	100%

For statistical analysis, the exact score for each individual student is subtracted from the average for the group.

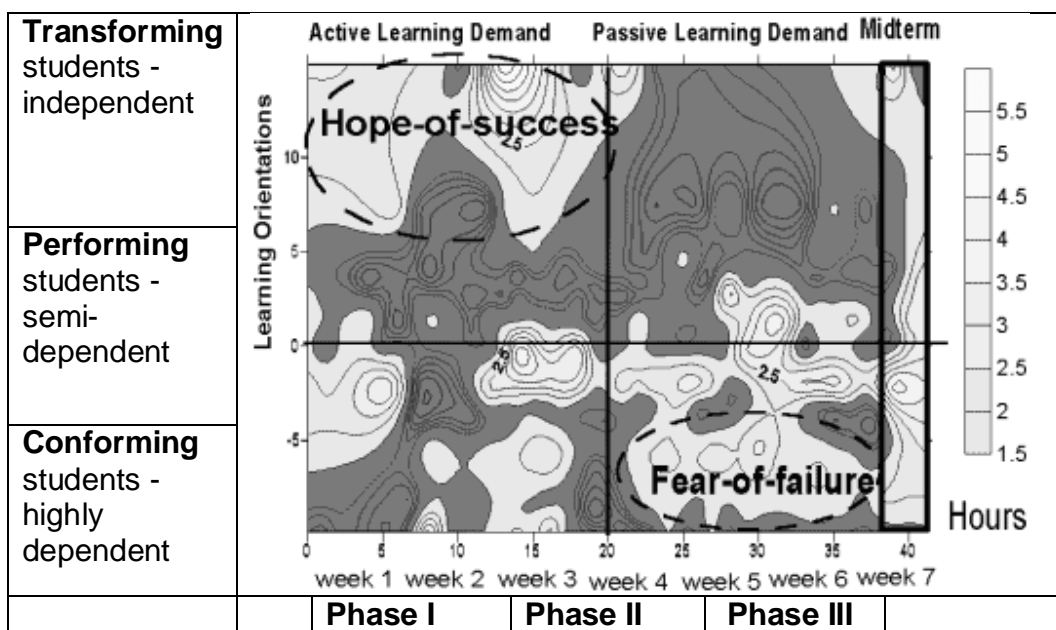
The deviations of students' learning orientations are indicated by positive values if they are above the average for the group, and with negative values if they are below it (the Oy axis of **Fig. 1**). The results of the study on students' learning demand are displayed by two variables: x and z. The horizontal axis (Ox) presents the day of students' visits. The axis Oz presents the time of each individual visit. This time is cartographically displayed on the contour map. The learning demand is the distribution of time invested by the students to study in the learning center as it depends on the day of the semester (x) and the learning orientation of the student (y).

The results of data-visualization presented in **Fig. 1** [3] are compared with respect to the distribution of patterns of behavior in **Table 3** [4]. At the beginning of the semester, the learning demand is considered pro-active. Students with learning orientation high above the average (transforming or global learners) are the most frequent users during the first half of the period of observation. However, the same students use the services less than one hour (under the sea level) during the second half of the period. The conclusion is that the group of independent learners was less interested in the learning services after the first three weeks. This is an indication that the developer of instruction needs special assessments to motivate transforming students to study in weeks 4, 5, and 6 of the semester. These assessments will help the high performing students who are also passive during the second half of the period of this study.

The group of conforming, or highly dependent students, will benefit from more structure at the beginning of the semester to avoid the "fear of failure" before the midterm. Also, the group of high performing students (above the average, but under the high transforming) will need motivation through the entire period. These students are capable and it is evident that they are not using the learning services.

For a better visualization, the duration of students' visits are divided into two groups, visualized as above the "see level" and below the "see level". Above the "see level" with different white/gray colors are presented the areas where the demand is more than one hour; in the dark gray areas (under the "see") the learning demand is less than one hour. On the map, the duration of students' visits is displayed with closed contours by software program "Surfer" (Golden Graphics). The contour map presents peak hours of students' visits as mountains, and the time with fewer students' visits as an ocean. The distribution of students' learning demand as it depends on the date of the semester and students' personalities has complex "land-shaft". The whiter areas are the so called peaks in learning demand. It is interesting that the white areas become absolutely solid during the midterm at the end of the period of observation, which is an indication that the program works well.

**Fig. 1: The map of students' learning demand [2] versus students' learning orientations measured by a Learning Orientation survey [8] (by Courtesy of Dr. Martinez, 2003)**



The components of the time series data as they appear on the map (Fig.1) are:

- Students who score high on the learning orientation questionnaire have pro-active learning demand; they invest more learning time at the beginning of the semester – the "hope of success" component.
- Students who score low on the learning orientation questionnaire have passive learning demand; they invest more learning time before the tests or at the end of the semester – the "fear of failure" component.
- High performing students do not use learning services frequently, while low performing use the learning services with constant intensity.

The analysis of the differences during the semester (in horizontal direction) shows two big hills - named "hope of success" and "fear of failure". These two peaks are indication for

developers of instruction to use multipurpose assessment instruments to address different learning needs. Although the peak denoted on **Fig. 1** as "hope of success" shows learning enthusiasm, it is a short-term enthusiasm. Global thinkers are very active at the beginning and later on usually compensate the lack of interest in tedious educational procedures with smart ideas and attempts to start new projects constantly. The goal of educators is to help those students to become more detail oriented.

The taxonomy of students' feelings [1] (**Table 3**) and the time data about the learning visits mapped on **Fig. 1** provide guidance for multipurpose time-management of learning devices online.

**Table 3: Students' learning experiences as they depend on the ratio between students' skills and learning challenges**

Challenges of the assessment	Student's personal learning skills		
	Low Skills - Phase I	Average Skills - Phase II	High Level Skills - Phase III
High Challenge (the choice of transforming students)	Anxiety (cell 11)	Arousal (cell 12)	Flow (cell 13)
Average Challenge (the choice of performing students)	Worry (cell 21)	Equilibrium (cell 22)	Control (cell 23)
Low Challenge (the choice of conforming students)	Apathy (cell 31)	Boredom (cell 32)	Relaxation (cell 33)

**Applications:** The results of the study are used for adapting the curriculum to the patterns of behavior of students' self-directed learning. How to use assessment instruments to guide students away from fear and anxiety towards "hope of success" depends on the instructor or developer of learning supplements. Do the students with learning orientations above the average level have natural "hope of success" type of attitude? Can the instructor or developer of online instruction, knowing the patterns of behavior of students in the group, design assessment instrument to lead students away from fear toward success? In the study the authors used some assessment instruments presented in **Table 4** with increasing success.

**Table 4: Research-based decisions on the appropriate learning devices for self-directed guide to improve the positivistic learning**

Time	Phase I -- the first two weeks of the semester	Phase II -- weeks three and four of the semester	Phase III -- weeks five, four and six of the semester
Assessment Instruments	Note taking of the new lesson and reading assessment	Concept maps and mind mapping	Creative workshops and project-based learning

In Phase I (**Fig. 1**), the strategic goal for conforming students should be to reach a certain level of relaxation (cell 33, **Table 3**). A future developer needs to figure out a strategy to avoid the so-called "fear of failure" peak in phase III. For this purpose, following the research-based guideline, Fuller and Krumova [4] developed a reading guide online for community college and university students enrolled in science classes. Students reported high satisfaction of the reading guides. To avoid some negative consequences of open-book assessment, such as figuring or locating the answers without any learning, the instructor could assign note-taking for the new lesson as a graded assignment.

In Phase II, along with the regular note-taking techniques, the instructor can add mind- or concept-mapping for the new lesson as an assessment instrument. The mind-mapping is a meta-cognitive procedure that will help students to make sense of the new material and to sharpen their attention and efforts in the direction of their personal challenges [8]. The purpose of mind-mapping assessment is to create personalized and self-directed learning plan.

During the second and the third phase, transforming students will benefit of more creative assessment instruments, such as Power Point presentations. This will fill the gap between the initial learning enthusiasm and the low activity during the weeks three to seven for the transforming students. To engage high performing and transforming learners in the flow (cell 13, **Table 3**) sophisticated workshops with a guest speaker may provide some impulse in the right direction. The artistic elements of student-teaching in front of the class could be used to create a united force in the direction of the flow in which high skills are balanced with high challenges. For example, a program for nuclear physics class for university students, developed by Krumova and Fuller [6], was applied successfully after the second week.

**Conclusion:** To increase the synergy between individuals and the educational institution, the educators need to consider the fine structure of students' natural learning preferences, feelings, and learning intentions throughout the semester. Although students have different learning preferences, the patterns of behavior during the first few weeks of the semester will provide research-based information for selecting the best assessment instruments as learning devices online.

## References:

- [1] Csikszentmihaly, M.; *Finding Flow: The psychology of Engagement with everyday life*, New York, HarperCollins Publishers, Inc., 1997, pp 17 – 31
- [2] Douglas, D. and Clark, J.; *Business Statistics*, Fourth Edition, Barron's Educational Series Inc., Hauppauge, NY, USA, 2003, pp. 419-449
- [3] Fuller, T.; *Students' Learning Demand*, 2005, URL: [http://www.learningdemand.com/marie\\_and\\_I.htm](http://www.learningdemand.com/marie_and_I.htm)
- [4] Fuller, T. and G. Krumova; *Online Reading Supplements for Atomic and Nuclear Physics Chapters of a General Chemistry Course*, In: *Proceedings of the Scientific Conference with International Participation*, Technical University of Varna, Oct 7-9, 2004, Varna, Bulgaria, Vol. 3, 2004, pp. 653-659
- [5] Jones, E. R. and M. Martinez; *Learning Orientations in University Web-Based Courses - a paper accepted for publication in the Proceedings of Web Net*, Orlando, Florida, 2001, Oct 23-27, 2003, URL: <http://www.tamucc.edu/~ejones/papers/webnet01.pdf>
- [6] Krumova, G. and T. Fuller; *Some Problems in Atomic and Nuclear Physics Education*, In:

*Proceedings of the Scientific Conference with International Participation*, Technical University of Varna, Oct 7-9, 2004, Varna, Bulgaria, Vol. 3, 2004, pp. 645-652

- [7] Leach, J. and P. Scott; Designing and Evaluating Science Teaching Sequencing: An Approach Drawing upon the Concept of Learning Demand and a Social Constructivist. *Perspective on Learning. Studies in Science Education*, 38, 2002, pp. 115-142
- [8] Martinez, M., Key; Design Considerations for Personalized Learning on the Web, *Educational Technology & Society* 4(1), 2001,  
URL: [http://ifets.ieee.org/periodical/vol\\_1\\_2001/martinez.html](http://ifets.ieee.org/periodical/vol_1_2001/martinez.html)
- [9] Massimini, F., and M. Carli; Systematic Assessment of Flow in Daily Experience, 1988. In: Csikszentmihaly, M.; *Finding Flow: The Psychology of Engagement with Everyday Life*, New York, HarperCollins Publishers, Inc., 1997, p. 31
- [10] Ramsden, P.; Student learning and perceptions of the academic environment, *Humanities, Social Sciences and Law*, Vol. 8, 4, 1979, pp 411-427,  
URL: <http://www.springerlink.com/content/k352247366u44780/>

## ADDRESSES

### Dr. Temenoujka Fuller

The Learning Center  
Central Arizona College  
9470 N Overfield Road  
Coolidge, AZ 85228  
USA  
Tel.: (520) 494 4979  
E-mail: [temenoujka.fuller@gmail.com](mailto:temenoujka.fuller@gmail.com)

### Assoc. Prof. Dr. Galina Krumova

Department of Physics,  
FEEEA,  
University of Rousse,  
Rousse - 7017  
Bulgaria  
Tel.: (+359 82) 888 215, 218  
E-mail: [gal@ru.acad.bg](mailto:gal@ru.acad.bg)

## АДАПТИВНИ УЧЕБНИ ИНСТРУМЕНТИ

Т. Фулър\*, Г. Крумова\*\*

\*Central Arizona College, USA, \*\*Русенски университет

**Резюме:** Тази работа представя структурата и динамиката на студентското учене за група от петдесет и един студенти от един колеж в САЩ. В специализиран учебен център е събрана времева серия от данни. Учебните предпочитания на студентите са оценени с помощта на анкета за учебната ориентация. Фината структура и динамика са представени с 3D карта, на базата на която са идентифицирани области на поведение, използвани за развитието на адаптивни учебни инструменти.

**Ключови думи:** Learning Theory, Synergy, Assessment Instruments, Need Analysis, Learning Demand, Learning Orientation.