2010

The Application of Little's Law to Enrollment Management: Improving Student Persistence in Part-Time Degree Programs

Ellen M. Walk
University of Richmond, ewalk@richmond.edu

Lewis A. Litteral
University of Richmond, llittera@richmond.edu

THE APPLICATION OF LITTLE'S LAW TO ENROLLMENT MANAGEMENT: IMPROVING STUDENT PERSISTENCE IN PART-TIME DEGREE PROGRAMS

Ellen M. Walk
Lewis A. Litteral
University of Richmond

ABSTRACT

Little's Law is applied to enrollment management in part-time degree programs. Using institutional data by program, on number of graduates per year, as well as number of credits taken and number of active students per semester, the calculated average time to graduation is compared to the average flow time predicted by Little's Law. Despite significant variability among students who enter with varying transfer credits and take varying credits per semester, Little's Law provides a simple model for measuring program growth trends, student productivity, and persistence to graduation. Implications for marketing, admissions, advising, course scheduling, and curriculum design are discussed.

INTRODUCTION

"Enrollment Management" often refers to recruiting and marketing to attract the appropriate students to academic programs. However, the challenge does not stop here. Universities with capacity constraints or excess capacity in specific schools or individual degree programs have enrollment management issues extending beyond recruitment and admissions. At the dean's level, the problem is to match the student demand for specific schools and majors with the supply of available faculty and seats in courses.

In traditional, full-time undergraduate and graduate programs, enrollments and progression to graduation are predictable, so the challenge is to match capacity (number of faculty, number of course sections offered, and number of seats available) to the projected demand. In contrast, in university schools of continuing and professional studies, students in part-time undergraduate and graduate degree programs enroll and progress toward graduation at much more variable rates.

There is a need to measure academic persistence and the intensity with which students take courses part-time, despite extreme variability among students in their paths to degree completion. Employers and governmental institutions wish to increase the number of work force participants with bachelors and graduate degrees, strengthening local and regional economies. In a recent publication of the University Continuing Education Association, "The New Face of Higher Education: Lifelong Learning Trends" (2009), it is noted that most states give much less consideration to adult students and the need for lifelong learning, than to traditional-age students. Furthermore, this report contends that economic development would be better served with grant programs for part-time students and improved strategies for transferring between two-year and four-year institutions. Sander (2008) discusses the Kentucky Adult Learner Initiative, and the California Postsecondary Education Commission (2006) reports on performance measures in an accountability framework for higher education in California.

Typical methods for measuring graduation rates do not take into account the more complex patterns of student retention and persistence for

a majority of college students, according to Capaldi, Lombardy, and Yellen (2006). Because the methods calculate the percentage of first-time, full-time students beginning undergraduate programs in the fall term, the federal government's reporting methods exclude part-time students and students who begin college in the spring or summer terms. In addition, transfer students appear as failures in their first institution, but do not appear at all in the statistics for subsequent institutions. Since a majority of undergraduate students do not graduate within four years, there appears to be a need for new metrics.

The national magnitude of the numbers of adult part-time students is notable. In "Adult Learning in Focus: National and State-by-State Data" (2008), research indicates that in 2004, adults made up about 43% of total enrollment at community colleges, full- and part-time. Between 1970 and 2002, adult part-time enrollment at all institutions increased from 7% to 12%, while at community colleges this increased from 17% to 26%. In addition to the economic benefits, this survey cites support for a relationship between educational attainment and civic involvement such as having the cognitive ability to process complex political and social issues, voting, and volunteering in the community. The survey, with state-by-state statistics, also reports significant gaps in data collection for adult students (defined by most studies as those 25 years of age and older), as well as insufficient data for younger postsecondary students with one or more characteristics such as attending part-time, financial independence, and working full-time while enrolled.

Universities are interested in students' persistence and degree attainment as an internal measure of program effectiveness. Practices in recruiting and admissions, as well as in student advising and efforts to integrate part-time students into the academic community, can be enhanced to support persistence and attainment more effectively. A school's capacity (the supply of course sections and number of seats per section) can be adjusted to match demand in a flexible manner, subject to the budget for faculty salary expenses. In some schools, demand proportionally influences tuition revenues in the school budget, so increasing part-time students' academic persistence (i.e., number of credits taken per semester) helps the students as well as the school. So matching supply and demand in academic operations is a key to managing enrollments in a cost-effective manner, and success or failure can be measured in standard budget reports.

Several of the sources cited in this section highlight the need for simple metrics that can be updated each semester to monitor changes in enrollments and student progress toward graduation. This also allows management decisions to be made in a timely manner in response. A simple and easy-to-understand model for any process is Little's Law. This operations research classic (Little, 1961) describes the relationship between work-in-process inventory in a system to the flow rate of finished product exiting the system and the flow time from entry to exit. The relationship can be expressed as:

Average Inventory = Average Flow Rate * Average Flow Time

Little's Law has been used to describe diverse operations including assembly lines and supply chains, batch processes, queuing and job shop processes in Cachon and Terwiesch (2006) and numerous other sources. Although many applications of Little's Law are found in production and customer service problems, the law has general applicability to any process with units of work in process in a pipeline.

However, no use of this model has been found in an education environment, such as in enrollment management. In this paper, this relationship between inventory, flow rate, and flow time is applied to describe the enrollment and persistence processes in part-time university

degree programs, from the time students enter to the time of graduation.

Using Little's Law, simple metrics can be developed depicting student behavior during their degree programs, not just upon entering at admission and exiting at graduation. This analysis enables more precise management decision-making, for example:

- As a revenue model, what impact do different tuition rates per credit hour, by program, have on the budget?
- Should an academic program be eliminated, how many students will be impacted, and how long will it take for the affected students to graduate?
- Should admission policies be changed, and what is the subsequent impact on enrollments?
- When and where do full-time faculty need to be added to enable the delivery of new programs?
- What impact does increased advising efforts have on student productivity?
- Which enrollments are increasing for traditional undergraduate students, certificate and graduate students?
- How can many more (or fewer) class sections are needed, based on changing enrollments?
- How can part-time students earn additional credits each year to shorten flow time?
- How can seasonality in enrollments be managed for better use of university resources and student time?
- How can four year universities prepare for increased enrollments from transfer programs at local community colleges?

LITERATURE REVIEW

The seminal article that proved the relationship between the average arrival rate to a system, the average time spent in the system, and average number in the system appeared in *Operations Research*, over 45 years ago, Little (1961). This result does not depend on the underlying probability distributions of the arrivals or the order in which items are serviced. Since that time, there have been many, many applications in a variety of settings. General discussions of the application of Little's Law and theory of constraints to Six Sigma and lean initiatives in operations and quality management appear in Gerst (2004), and Godfrey and Bandy (2005). Tu, Chao, Chang, and You (2005) used Little's Law in an electronic wafer foundry to determine backup capacity to overcome bottlenecks in the production process. In the residential construction industry larger homebuilders sometimes view their production system as an assembly line process. It is in this context that Bashford, Walsh, and Sawhney (2005) examine the relationship specified by Little's Law to account for characteristics of construction projects that affect project performance and the resulting financial performance of the company. An important extension of Little's Law for situations where the long term, steady state relationships between average flow time and inventory do not hold but, instead the investigation of observed results over finite time periods (such as the sequences of semesters examined in this paper) are of interest, can be found in Kanet (2004).

We found no record of the application of Little's Law to enrollment management. Nonetheless, educational research on student retention and academic persistence is interesting and pertinent to the problem of managing student enrollments from admission to graduation. A survey on terms and definitions for college student retention, as well as predictors of student retention, can be found in Bean (2003).

Much of the current research in enrollment management research focuses upon marketing techniques. Bassin and Sellner (1997) present a step by step method to forecast the enrollments of college students who are well prepared as defined by a certain criteria. Bruning (2002) looked at enrollment management in the context of retention of existing students. His work showed that the attitudes held by the students regarding the public relationships of the

university were important determinants in whether or not a student returned for the next year. Imenda and Kongolo (2002) examined the factors that explained a South African university's ability to sustain and raise its student enrollment levels against declining national enrollment in its category.

Peter, Cataldi, and Carroll (2005) studied the extent to which undergraduates attend multiple institutions as well as the relationship between multiple institution attendance and persistence, attainment, and time to degree. Their datasets included 1) students who enrolled in postsecondary education for the first time in 1995-1996, and 2) students who received bachelor's degrees in 1999-2000 regardless of when they began postsecondary education. This multivariate analysis takes into consideration the myriad factors causing the underlying variability that is considered to be a given in part-time bachelors degree programs in four-year institutions.

Sara Goldrick-Rab (2007), in a Community College Research Center working paper, describes student characteristics, as well as state and institutional practices and policies, that interact to promote or impede student persistence toward degree completion. These characteristics include choice of courses and attendance patterns, as well as financial aid and transfer policies.

Capaldi, Lombardy, and Yellen (2006) describe the "tracking program" at the University of Florida, including process metrics that impact the eventual graduation rate for undergraduates, such as improved advising, simplification of curricular options, and earlier choice of majors. As a result of this tracking system, teaching schedules were modified to ensure a sufficient number of seats in required courses as needed by students, instead of allowing faculty to teach courses when they wanted to teach them. Also there was a dramatic drop in add/drop activity ("churning") at the beginning of each semester, indicating a better match between supply and demand for courses.

In "Adult Learning in Focus: National and State-by-State Data" (2008), research by the Council for Adult and Experiential Learning, in partnership with the National Center for Higher Education Management Systems, a case is made for improved metrics for measuring success of adult learners. State policymakers are interested in an educated workforce to support the economic needs of families, to attract new kinds of business, and to contribute to tax revenues and economic competitiveness in their region. However, federal and state policy remains focused on the productivity of traditional students in attaining each educational level. This report cites gaps in data collection for adult students (defined by most studies as those 25 and older) and for younger postsecondary students with one or more characteristics like those 25 and older (e.g., attend part-time, financially independent of their parents, work full-time while enrolled). The number of credits taken is suggested as a measure of efficiency in postsecondary education in lieu of graduation rates and time to degree. This is one metric used in the long-term study presented below, among others, to monitor part-time adult students' productivity and persistence to degree.

METHODOLOGY

This data collection proceeded in two phases. First, during an undergraduate operations management class project in fall 2006, students applied Little's Law to analyze demand in the University of Richmond School of Continuing Studies' degree programs over a multi-year period, fall 2002 – fall 2006. A decision support system extracting enrollment data from the university database into Excel was used by administrators and the students to analyze flow rates, inventory of active majors, and flow times through degree programs, by degree program in each department.

Based on the initial analysis of data, the enrollment processes were determined to be seasonal, and quite different in the summer. Fall-spring enrollments were analyzed as one process, and summer enrollments were treated as a separate process. The data from the first phase thus served as the historical baseline.

In the second phase of data collection extending from spring 2007 to fall 2009, department chairs began to implement management decisions to improve student productivity and persistence to graduation in these part-time degree programs. Enrollment data during the second phase from spring 2007 to fall 2009 was and continues to be tracked to see the effect of these management decisions:

- In fall 2007, there was a curriculum change in all undergraduate degree programs to simplify student choices, eliminating some small degree programs and funneling these students into the larger bachelors programs.
- In fall 2007, requirements in the general education and the major were streamlined for all undergraduate degree programs in the University of Richmond School of Continuing Studies to increase clarity and the feasibility of these degrees for prospective transfer students.
- In fall 2007, selected certificate programs for post-bachelors students were shortened from 30-36 credits to 21 credits.
- Because of a tendency in the school to have too many course sections with low enrollments, the number of courses scheduled each semester was reduced, and a projected fall-spring-summer course rotation was publicized to all students, in an attempt to simplify choices.
- Marketing initiatives to prospective students became more quantitative in nature, as marketing staff began tracking the progress of prospective students being admitted by degree program each semester. Department chairs were in a better position to determine the target number of new students to replace graduates, and to assess actual admission numbers year-to-date versus targets.

In the Department of Information Systems, additional efforts were made during the period from spring 2007 to fall 2009 to improve productivity and persistence. All advising, curriculum, and scheduling modifications were intended to increase the number of credits taken by Information Systems majors each semester.

- Most students in the major developed an individual course plan for the remaining semesters to graduation, providing the department chairman valuable information about course preferences and desired rate of progress through the degree program.
- Students were encouraged to plan and take more credits in summer terms.
- In Fall 2009, additional curriculum revisions were piloted, including more four-credit courses to replace selected three-credit courses, allowing working students to be more productive each semester with a manageable part-time course load.
- Relationships with specific community college programs were expanded to facilitate and encourage transfer into the bachelor's degree programs in information systems.

Metrics Used for Adult Student Productivity and Persistence: Using Little's Law, the three variables of interest are: the **inventory** of units that are resident in a process, the **flow rate** at which these units travel through a process, and the **flow time** it takes a unit to proceed from start to finish in a process. In this study, the following metrics were used for measuring student productivity and persistence from fall 2002 to fall 2009:

Inventory: The number of active students in each degree program by semester was determined.

Flow Rate:

a) One flow rate metric for "product exiting the process" was the number of graduates per year, by degree program in each department.

b) A second flow rate metric was number of credits taken per semester, measuring how productive students in a particular degree program were over time. (This second metric correlated directly with tuition revenues, as well.)
c) A third flow rate metric was number of credits taken **per student** per semester. This was simply the number of credits taken divided by inventory of active students, in each degree program.

Flow Time: For each individual student, the flow time was calculated as the number of years between the term of admission and the term of graduation. The variability in students' flow times was calculated with a histogram and cumulative distribution table showing what percentage of these part-time students graduate within two, three, four or more years of entering a degree program. Student flow times varied widely, depending on transfer credits and number of credits taken per semester.

Excel Analysis: For graduation flow rates and flow times, a database administrator retrieved the relevant fields of source data, from the university database into Excel, including degree program, major department, admit term and graduation term for each graduating student in this time period. For the number of credits taken as well as the inventory of active students, anonymous data about each course completed by each student each semester were retrieved, including fields used for classification such as degree program and major department. This was an opportunity for the undergraduate operations management students to analyze a large amount of realistic data, and to experience Excel functions like filters, lookup tables, sorts, subtotals, IF statements, and histograms.

The calculation of flow time to graduation was determined to be more complicated due to the way admit terms were entered in the university database. Care was taken in calculating flow time to determine when a student started taking courses in a degree program. In some continuing education programs, adult students can take classes as non-degree-seeking students, so admit term does not necessarily indicate when the student started taking courses, but rather when a student was admitted and under what catalog. This analysis was done after the first phase of data collection only. During the second phase of data collection, flow time was chosen to be the variable predicted by the other two variables that were easier to measure, inventory and flow rate.

RESULTS

The bachelor's, certificate, and graduate degree programs in the University of Richmond School of Continuing Studies are part-time programs for working adults. Students generally take an average of a little more than two undergraduate courses per semester, or one graduate course per semester. As a representative department showing the full analysis, results are reported for the bachelor's and certificate degree programs in Information Systems only. The bachelor's degree is 120 credits, of which at least 60 credits have to be taken at the University of Richmond. The certificate in Information Systems is comprised of a 21-credit set of undergraduate courses taken by students who already have a bachelor's degree and wish to switch careers or to take prerequisites for graduate study.

The Department of Information Systems experienced non-stationary enrollments from 2002 to 2005, due to a national downward/flat trend in computer science and information systems in most universities during this period following the dot.com bust and recession. From fall 2005 to fall 2009, enrollments were essentially stable, until another recession began in 2008. Sample results for the bachelor's degree program in the Information Systems department are summarized below.

The department also had seasonal enrollments in the fall, spring and summer. Fewer students were active in the summer semester, some wanting to take a break, some balking at the

compressed terms, some lacking financial aid for the summer, and some preferring to spend time with children on summer vacation.

Based on initial analysis of data from fall 2002 to spring 2007, data from fall and spring were separated from summer data, as the enrollment processes were different.

Inventory of Active Students

Figure 1 illustrates the number of active students in the Information Systems degree programs by semester. This reflects the drop in enrollments nationwide experienced in information systems as well as computer science during this period. Because adult students are in the pipeline longer, however, this moderates the effect on enrollments. Also, individuals changing careers enrolled in the certificate program have increased in numbers since spring 2008, possibly due to demand in the workplace and to the shortened program.

Flow Rate in Number of Graduates Per Year

In Table 1, the number of graduates per year is listed for the Information Systems degree programs. For part-time working adult students this is preferred to a graduation rate used for traditional undergraduate programs because there is no entering cohort, yet the final measure of success, degree attainment, is tracked in this way.

Flow Rate in Total Number of Credits Taken Per Term

Figure 2 illustrates the total number of credits taken by students in a degree program partly reflects the number of active students and the aggregate productivity of these students. When viewed by degree program in each department, it indicates the relative contribution and scope of each degree program in a school. Larger degree programs, or growing degree programs, can be monitored as critical success factors; struggling degree programs can be re-evaluated, and resources can be re-allocated to more effective uses.

Figure 1. Inventory of Active Students by Term Fall and Spring Terms
Information Systems Major

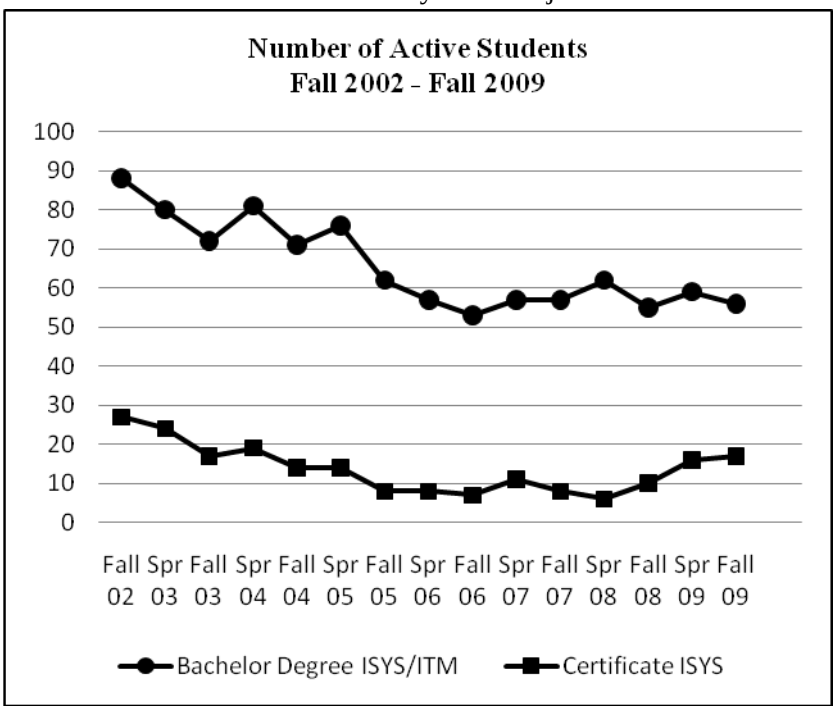
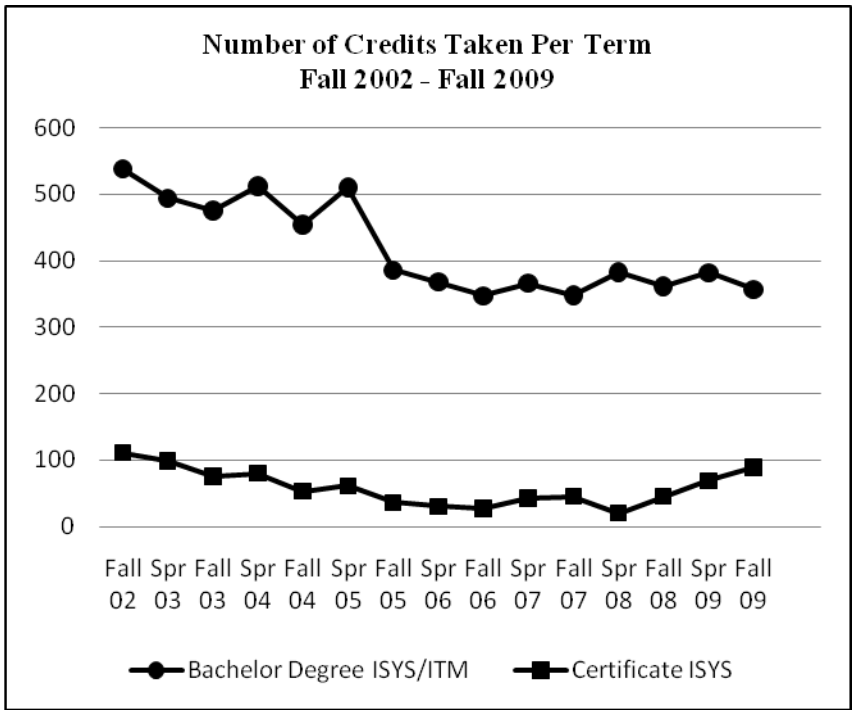


Table 1. Flow Rate - Number of Graduates Per Year
Information Systems Major

Includes December, May, and August Graduates Each Academic Year

	Bachelors	Certificate
2002	13	7
2003	15	9
2004	19	2
2005	15	4
2006	19	3
2007	14	3
2008	6	5
2009	12	3

Figure 2. Flow Rate – Number of Credits Taken Per Term
Information Systems Major



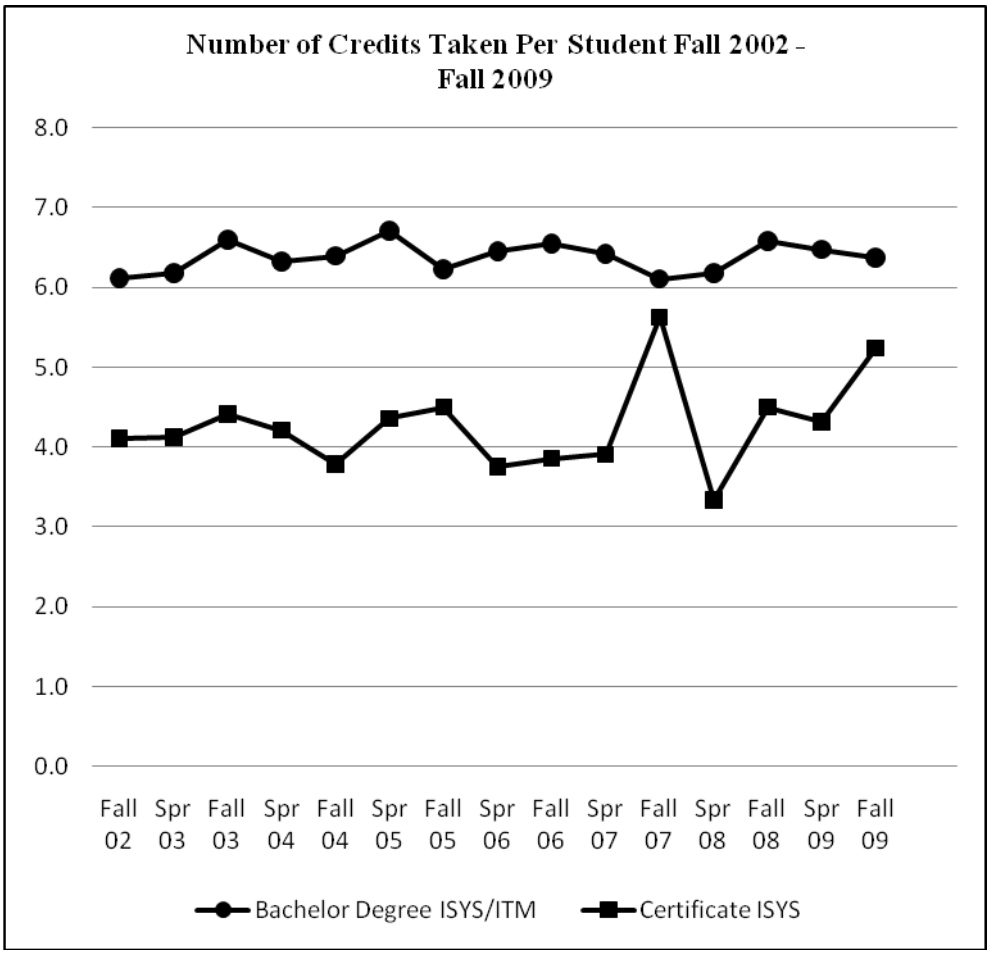
Flow Rate in Average Number of Credits Taken Per Student Per Term

Figure 3 illustrates the average individual student productivity and progress of these majors toward degree completion. This metric can have implications for student advising and communications. The lower number of credits taken per certificate student is a reflection of the higher-level jobs these students hold, and is influenced by the smaller number of active students. It is too early to tell what impact the new four-credit courses (begun in Fall 2009) will have on this metric.

Comparison with the Summer Enrollment Process

Summer enrollments were also tracked during this period. Table 2 shows the different patterns of student productivity and persistence in the summer, compared to fall and spring. With the existing course rotation, intensive scheduling, and term dates, it has been difficult to increase participation of more students in the summer, even though this clearly is a way to shorten time to degree. (After advising and scheduling efforts in Information Systems, the same students took heavier workloads in the summer.)

Figure 3. Flow Rate - Number of Credits Taken Per Student Fall and Spring Terms
Information Systems Major



Flow Times to Graduation

Graduates exiting the Information Systems bachelor's degree program from spring 2002 – spring 2006 (the first phase of data collection) reflected admissions starting about five years previously, as indicated in the cumulative distribution of flow times (Table 3) and the histogram shown in Figure 4.

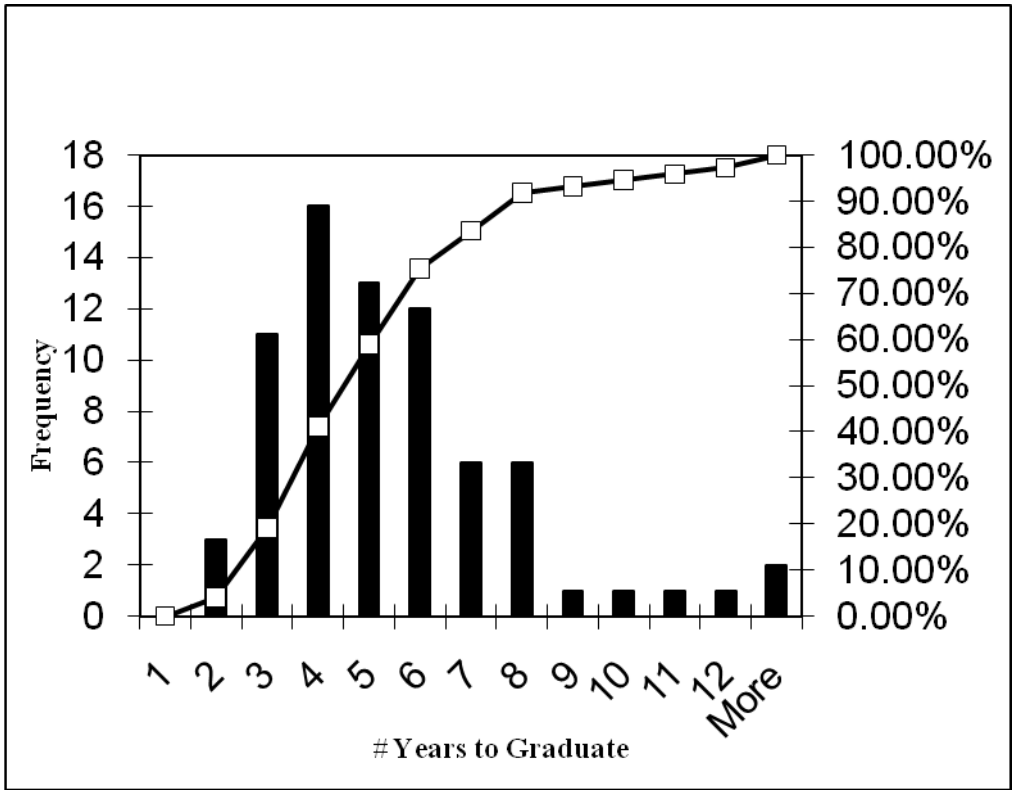
Table 2. Inventory and Flow Rate Measures in Summer Terms
Information Systems Major

	Number of Active Students		Number of Credits Taken	
	Bachelor's	Certificate	Bachelor's	Certificate
Summer 2003	34	5	147	14
Summer 2004	38	5	200	25
Summer 2005	32	1	151	1
Summer 2006	20	1	98	1
Summer 2007	31	2	156	6
Summer 2008	34	2	192	9
Summer 2009	31	10	216	39

Table 3. Student Flow Times to Graduation 2002 - 2006
Bachelor's Degree - Information Systems Major

# Years to Graduate	Frequency	Cumulative %
1	**0**	**0.0%**
2	**3**	**4.1%**
3	**11**	**19.2%**
4	**16**	**41.1%**
5	**13**	**58.9%**
6	**12**	**75.3%**
7	**6**	**83.6%**
8	**6**	**91.8%**
9	**1**	**93.2%**
10	**1**	**94.5%**
11	**1**	**95.9%**
12	**1**	**97.3%**
13	**0**	**97.3%**
14	**0**	**97.3%**
15	**2**	**100.0%**

Figure 4. Student Flow Times to Graduation 2002-2006
Bachelors Degree - Information Systems



When flow times were analyzed (Table 4) for graduates in the years 2002-2006, we found the predicted average flow time to graduation using Little's Law to be somewhat lower than the actual average flow time, but closer to the actual median flow time to graduation for this degree program. As discussed previously, this is a tedious analysis, so each year the transcripts of Information Systems graduates are analyzed briefly to estimate the average flow time of the graduating class. In 2009, students graduating with a bachelor's degree in Information Systems had an average flow time of about 4.5 years, which was expected given the stability in number of active majors and number of credits taken per semester, as well as similar behavior in the number of credits transferred into the bachelor's degree from previous institutions.

Table 4. Actual Versus Predicted 2002-2006
Average Inventory, Flow Rate, and Flow Time
Bachelor's Degree- Informational Systems Major

	ACTUAL	PREDICTED (LITTLE'S LAW)
Average Inventory of Active Students *	69.7	
Average Flow Rate, Graduates per Year (May & August	16.2	
Average Flow Time to Graduation, Years	**5.2**	**4.3**

DISCUSSION

This analysis can be replicated by administrators utilizing institutional enrollment data and spreadsheet analysis. When deans and department chairs become knowledgeable about the number of active students (inventory in Little's Law), number of graduates per year and number of credits taken per semester (flow rate), and the estimated flow time to graduation, improved decisions can be made. The metrics in this paper are vital for continuous program assessment:

(1) To maintain enrollment levels, the number of annual admits must replace the number of annual graduates—understanding this flow rate metric allows concrete recruiting and admission goals to be set if increased (or decreased) enrollment is desired.
(2) In some degree programs, when there is a capacity constraint on enrollment, the number of active students in the program as well as the number of graduates per year must be tracked.
(3) Graduation rates and flow times to graduation are needed for continued program assessments.
(4) In part-time degree programs, these flow rates are directly tied to tuition revenues. Expanding this analysis for all degree programs facilitates development of alternative revenue models and supports effective budget management.

This analytical approach continues to be used for managerial decision-making in the following ways in the University of Richmond School of Continuing Studies, especially in the Department of Information Systems. An additional staff member has been hired to work with community college program directors to facilitate marketing efforts. Understanding the aggregate demand from part-time students resulted in improved course scheduling, matching the supply of seats with the demand. Capacity utilization of available seats improved; by reducing the number of low-enrollment sections, the number of students per section increased moderately. Student course planning and tracking completion of degree requirements will soon be available online for students using the university registration database. Curriculum revisions to remove unintended road blocks to degree completion were implemented, and selected four-credit courses are likely to help students improve flow rates and flow times to graduation in the future. Efforts promoting use of the summer to earn credit will continue. Enrollments were increasing as of fall 2007, due to external industry conditions, and as the economy improves these metrics will be watched closely. This analytical technique will continue to be used to track the effect of all of these factors on student productivity in degree programs, and signal when changes to capacity and other managerial actions may be needed.

DIRECTIONS FOR FUTURE RESEARCH

There are several questions to be investigated in future research. First, this analysis can be replicated with existing historical data for other undergraduate and graduate degree programs at the University of Richmond in the School of Continuing Studies, such as:

- the graduate certificate and master's degrees in education,
- the undergraduate, graduate certificate, and master's degrees in human resource management
- the bachelor's and certificate degree in paralegal studies
- the part-time and full-time undergraduate degrees in liberal arts

It would be interesting to compare the undergraduate applied/professional degree programs on the whole (information systems, human resource management, and paralegal studies) to the undergraduate liberal arts programs, to see whether there are differences in student flow rates and flow times to graduation. It is known that a majority of the undergraduate students in the School of Continuing Studies

complete primarily their junior and senior years here, using these programs for degree completion, but there are some differences between the professional programs and the more general liberal arts programs.

Second, the use of four-credit courses in Information Systems, begun in fall 2009, has the potential to increase the number of credits that part-time students can take while balancing work and personal demands. Updates to this data as of the end of the spring 2010 term will be completed in the near future. Preliminary estimates indicate that the number of credits per student increased in spring 2010 in the bachelor's degree program in Information Systems. This increase was observed for certificate students in Fall 2009.

Third, the use of online courses in the Information Systems program will be reduced starting fall 2010. Currently several general education courses can be taken online, but only a few Information Systems electives can be taken online. While online courses clearly have helped students in Information Systems to take more courses per semester, reducing travel time to campus as well as night conflicts between courses students might need in the same semester, the use of four-credit courses on campus will be used more in the immediate future to help students take more credits per semester. There is adequate classroom capacity on campus now in the evenings to run this degree program at its present size, with room for growth.

Fourth, an increased use of scholarship aid to promote access and productivity in the future may have an impact on persistence and time to degree completion in the University of Richmond's School of Continuing Studies. Currently, part-time students are eligible for student loans when they enroll for six credit hours. Students are eligible for the Virginia Tuition Assistance Grant when they enroll for twelve credit hours or more (this is grant aid from the State of Virginia to students who attend private universities full-time). The variable cost for tuition does not change in the University of Richmond's School of Continuing Studies. There is a flat per credit hour tuition regardless of how many credit hours the student takes. Between six and twelve credit hours, there is no financial advantage for students to take a few more credit hours per semester, to reduce their flow time. (The incentive for the student is earlier degree completion, however, which may result in increased salary and job promotion.) Scholarship aid may fill this gap, to improve persistence and time to degree.

Finally, it should be noted that changes in the economy, for better or for worse, will impact persistence and time to degree in the future. Different degree programs and majors move in different directions depending on the economy, and on the loss or gain of organizations in industry or government agencies employing these students. An improved economy may make it possible for unemployed students to afford to take more courses, yet students may become busier on the job when this occurs. The use of Little's Law and the metrics in this paper allow administrators to see what is going on in degree programs with readily available data in a timely manner for decision-making.

REFERENCES

1. *Adult learning in focus: National and state-by-state data*. (2008). Retrieved March 20, 2010, from http://www.cael.org/adultlearninginfocus.htm.

2. Bashford, H. H., Walsh, K. D., & Sawhney, A. (2005). Production system loading--cycle time relationship in residential construction. *Journal of Construction Engineering and Management*, 131(1), 15-22.

3. Bassin, W. M., Sellner, R. G., & Bickers, D. (1995). How to prepare forecasts of enrollments of first year

students. *The Journal of Business Forecasting Methods & Systems*, 16(1), 17-22.

4. Bean, J. P. (2003). College student retention. *Encyclopedia of Education.* Ed. James W. Guthrie. Vol. 1. 2nd ed. New York: Macmillan Reference USA, 401-407.

5. Bruning, S. D. (2002, February). Relationship building as a retention strategy: Linking relationship attitudes and satisfaction evaluations to behavioral outcomes. *Public Relations Review* 28.1: 39(10).

6. Cachon, G. & Terwiesch, C. (2006). *Matching supply with demand: An introduction to operations management*. New York, NY: McGraw-Hill/Irwin.

7. California State Postsecondary Education Commission. (2006). *California higher education accountability: Goal—student success measure--time-to-degree*. Commission Report 06-20. Retrieved from ERIC database.

8. Capaldi, E., Lombardi, J., & Yellen, V. (2006). Improving graduation rates: A simple method that works. *Change: The Magazine of Higher Learning*. 38(4), 44-50. Retrieved from ERIC database.

9. Dee, T. S. (2004). Are there civic returns to education? *Journal of Public Economics.* 88: 1697–1720.

10. Gerst, R. (2004, February). The little known law. *ASQ Six Sigma Forum Magazine.* 3(2), 18-23. Retrieved March 20, 2010, from ABI/INFORM Global. (Document ID: 572134771).

11. Godfrey, M. R. & Bandy, D. B. (2005, February). Applying Little's law and the theory of constraints. *ASQ Six Sigma Forum Magazine*. 4(2): 37-41. Retrieved March 20, 2010, from ABI/INFORM Global. (Document ID: 809418541).

12. Goldrick-Rab, S. (2007). *Promoting academic momentum at community colleges: Challenges and opportunities.* CCRC Working Paper No. 5. Community College Research Center, Columbia University, Retrieved from ERIC database.

13. Imenda, S. N. & Kongolo, M. (2002). Sustained student enrollments at a historically white South African university: A case study of Rhodes University. *Journal of Higher Education Policy and Management,* 24(2), 219-30.

14. Kanet, J.J. (2004). Mean flowtime and inventory in production systems: A finite time analogue to Little's Law. *International Journal of Production Economics*, 91(1), 37-46.

15. Little, J. D. C. (1961). A proof of the queuing formula $L = \lambda W$. *Operations Research*, 9, 383-387.

16. Peter, K. & Cataldi, E. (2005). *The Road less traveled? Students who enroll in multiple institutions. Postsecondary education descriptive analysis report.* National Center for Education Statistics (ED), W., & MPR Associates. National Center for Education Statistics. Retrieved from ERIC database. B NCES 2005-157.

17. Sander, L. (2008). Colleges woo adults who have some credits but no degree. *Chronicle of Higher Education*. 54(23): A29. Retrieved from ERIC database.

18. Tu, Y., Chao, Y., Chang, S., & You, H. (2005). Model to determine the backup capacity of a wafer foundry. *International Journal of Production Research,* 43(2), 339-359.

19. *The new face of higher education: Lifelong learning trends.* (2009). University Continuing Education Association.

ABOUT THE AUTHORS

Ellen M. Walk is Assistant Professor of Information Systems and heads the Information Systems and Business program in the School of Continuing Studies at the University of Richmond. Born in Spartanburg, SC, she holds a B.S. in Chemistry from the College of William and Mary, an M.B.A. from the University of Richmond, and a Ph.D. in Business from Virginia Commonwealth University. She teaches information systems and operations management in the Robins School of Business at the University of Richmond. Her research interests are lean service operations, database management systems, and collaborative information technologies.

Lewis A. Litteral is Associate Professor of Management in the Robins School of Business at the University of Richmond. He holds a B.S. in Mathematics from Georgia Southern College, a M.S. in Mathematical Sciences and Ph. D. in Management Science, both from Clemson University. He teaches courses in operations management and statistics at the undergraduate and MBA levels. His research interests in forecasting and statistical quality control have most recently resulted in publications in the *International Journal of Production Economics*, *Quality Engineering*, and the *International Journal of Quality and Standards.*