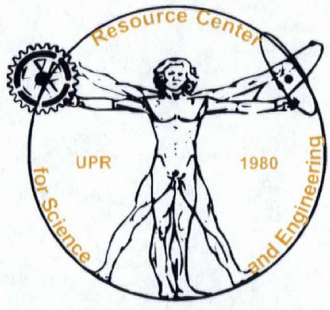
Puerto Rico Louis Stokes
Alliance for Minority Participation

Measuring The Effectiveness and Efficiency of SMET Programs: The Index of Course Efficiency (ICE)



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Measuring the Effectiveness and Efficiency of SMET Programs: The Index of Course Efficiency (ICE)

Why do we need to measure effectiveness and efficiency?

- We want to change the institutional culture - a systemic approach
- We want to impact ALL students
- We want the changes to be permanent

Three metrics to measure effectiveness and efficiency

PR-LSAMP has been using three metrics:

- Graduation Rate
- Number of Years to Obtain a BS Degree
- The Index of Course Efficiency (ICE)

The Index of Course Efficiency (ICE)

We define the Index of Course Efficiency as the average number of times students must take a course to satisfactorily pass it

Why is ICE important?

- It helps to identify problem courses at the institution
- It measures the impact of the problem courses (e.g. an ICE of 2 -vs- an ICE of 4)
- Low levels of course efficiency undermine the students' chances for successful graduation

How do you measure ICE?

$$ICE = \frac{\text{Total number of times course is taken}}{\text{Number of students who approved the course}}$$

The Ideal ICE Index

The ideal situation is an ICE = 1

Each student that takes the course obtains a satisfactory grade in the first attempt.

Methodology to Obtain Metrics

- Cohort Study
- Retrospective Cohort Study

Cohort Studies

A Cohort Study:

Tracks a specific group of individuals through a process. The sample is selected at the initial moment and followed through all events.
Group = undergraduate SMET students
Process = undergraduate careers

Retrospective Cohort Studies

A Retrospective Cohort Study:

- Records are obtained of all individuals who embarked on the process (only data on students that entered the institution as freshman is used)
- a random sample is selected
- the study is conducted.

Advantages of a Retrospective Cohort Study

- It permits to conduct the study quickly without waiting for the cohort to complete the process
- In some cases it is the only possible procedure if you missed the opportunity to get the sample at the outset.

What PR-LSAMP Did

- Opted for a retrospective cohort study
- The registrar office provided the records of all students that declared a SMET major when entering the institution (first year students) and a random sample was selected
- Date of entry was established - Transcripts were selected from students who had entered at least 6 years previously

Information Obtained from Student Records

- Entrance date
- Initial field of study
- Time in SMET fields
- Graduation date
- Degree awarded (with specialty)
- Final grade point average (GPA)

Data Obtained for Each SMET Course

- Satisfactory grades on first attempt
- D, F, W, and I obtained
- Number of times the course was repeated
- Number of successful final results

ICE Helps to Identify Problem Courses

Gatekeeper Courses = Those courses that impede the entry of SMET students in their chosen academic career
Bottleneck Courses = Those courses that impede the completion of a SMET career once entered upon by the student

These courses have large numbers and high percentages of students who:

- Do not obtain a satisfactory grade in the first attempt
- Have difficulty obtaining a satisfactory result when repeating the course

ICE Tells You the Impact of the Problem Course

Also, ICE data tells you on the relative ease or difficulty of successfully repeating problem courses:

- The impact of the problem courses
- The cost to the institution and to the students of these problem courses

The ICE Tables

The ICE tables include:

- An institutional identifier, the year of entry of the cohort, the number of records it comprised, and course code
- Total enrollment in the course per year
- Satisfactory outcomes on first attempt (number and percent of total)
- Unsatisfactory outcomes on first attempt (number and percent of total)

The ICE Tables

The ICE tables include:

- Number of times course was repeated (the total number of attempts after the first try by all students)
- Number of students that satisfactorily completed the course in more than one attempt and as percentage of the number of students who obtained an unsatisfactory outcome the first time
- Number and percentage of students who never obtained a satisfactory grade

The ICE Tables

The ICE tables include:

- The percentage of those for whom the final result, whether after one or multiple attempts, was unsatisfactory
- The Index of course efficiency (ICE), which quantifies the effect of the problem courses for the institution (To get the ICE you divide the total times the course was taken, regardless of the result, by the number of successful results)

The ICE Index

- An Index of "1.0" is the ideal (every student that takes the course passes it on the first attempt).
- As the ICE rises, it shows that the course requires increasingly greater institutional resources (e.g. faculty time, classroom space, etc.) to produce one satisfactory exit from the course

What The ICE Index Means

- For example, an ICE of 4 means that, on the average, students must take the course 4 times in order to pass it. To the institution it also means that they must give the course to four times as many students (either as first-time takers, repeaters, or a combination of the two) to eventually have course graduates with a satisfactory grade.

Two Other Metrics

In addition to the ICE, the retrospective cohort study allowed us to obtain information on two other metrics:

- The average number of years it takes a student to obtain a SMET degree
- The graduation rate for the cohort

Comparison of Graduation Rates in SMET for Two Cohorts

Institution	Graduation Rate Cohort Entering In 1983-86	Graduation Rate Cohort Entering In 1991	No. of Years To Graduate 1983-86 Cohort	No. of Years To Graduate 1991 Cohort
Institution 1	28.3% (83-86)	42%	5.8	4.7
Institution 2	37% (1984)	46.7%	5.0	5.4
Institution 3 Eng. Majors	53% (83-86)	76%	6.1	5.5
Institution 3 Science Majors	39.6% (83-86)	46.6%	5.0	5.3
Institution 4	37% (1984)	49%	4.7	5.2
Institution 5	50% (1984)	65%	4.8	5.0
Institution 6	11.1% (1985)	50%	Not available	6.5

Creating Awareness of the Problem

These metrics allowed us to create an awareness among presidents and chancellors of the need to transform SMET undergraduate education, and to promote simultaneous top-down and bottom-up reform strategies.

PR-LSAMP Reform Strategies

EXAMPLES OF TOP-DOWN AND

BOTTOM-UP REFORM STRATEGIES

PR-LSAMP Top-Down Strategies

- The student is made the center of the teaching and learning process
- Learning communities are nurtured to study, analyze, and improve the teaching/learning enterprise
- Funds are made available for curricular improvement and strategies

PR-LSAMP Top-Down Strategies

- An assessment and accountability system is put in place
- SMET courses with high attrition and failure rates are restructured to increase their effectiveness
- R&D is strategically strengthen and student participation in the research endeavor has been increased
- Metrics for assessing the progress of the reform are established

PR-LSAMP Bottom-Up Strategies

- Use of Cooperative Learning and other teaching strategies by faculty to improve student academic performance
- Curricular innovations are put in place by the faculty at participating institutions
- Use of technology to reinforce the teaching/learning process, such as the use of the graphic calculator in SMET courses

PR-LSAMP Bottom-Up Strategies

- Faculty members follow an experimental design, rather than a cookbook approach in laboratory experiences
- Concepts are put into the context or real world situations
- New assessments strategies are being used, such as performance-based activities to test for depth of understanding and mastery of basic concepts
- Faculty is promoting the development of entrepreneurial skills in their courses

WHAT HAVE WE ACHIEVED?

COMPARISON OF ICE NUMBER

FOR TWO COHORTS

Example #1: Institution #2 ICE Numbers for Two Cohorts 1983-85 and 1991

Course	1983-85	1991
Biol 222	2.3	1.9
FISI 211	3.5	3.5
FISI 212	2.3	1.8
MATE 141	2.3	1.8
MATE 272	2.3	1.6
CHEM 201	2.1	1.2
CHEM 231	5.2	1.6

To Summarize...

- The ICE index helps you identify your "problem" courses
- The ICE Index shows you the impact of the problem course
- The higher the ICE number in your courses, the higher the possibility of losing students from SMET careers

If the ICE Index is Reduced ...

- You increase the institution's retention and graduation rates in SMET disciplines
- You will have a considerable economy in institutional resources
- You will facilitate departmental planning and projections of staff and space, since you will not have many students taking the course out of an ideal sequence

The Outcome

IMPROVED
EFFECTIVENESS AND EFFICIENCY

OF SMET PROGRAMS

PUERTO RICO ALLIANCE FOR MINORITY PARTICIPATION
INDEX OF COURSE EFFICIENCY
SCIENCE, ENGINEERING AND MATHEMATICS COURSES

						RESULT FOR STUDENTS WITH D, F, W, I ON 1st ATTEMPT						
Inst. #4	Average	Satisfactory		Unsatisfactory		No. of Times	Satisfactory		Unable to Complete		Final Result	Index of
3 Cohort	Enrollment	Outcomes (A,B,C)		Outcomes (D,F,W,I)		Course	Completed Course in		Course Satisfactory		Unsatisfactory	Course
Averages	for Cohorts	On First Attempt		On First Attempt		Was	More Than One Attempt		In One or More Attempts		(D, F, W, I)	Efficiency
	1983-85	Number	% of Total	Number	% of Total	Repeated	Number	% of Unsat	Number	% of Unsat	as % of Total	(1.0 ideal)
Course Codes												
BIOL 3011	72	50	69%	22	31%	34	9	39%	13	61%	19%	1.8
3012	59	48	81%	11	19%	16	6	53%	5	47%	9%	1.4
3305	18	15	83%	3	17%	3	0	11%	3	89%	15%	1.4
3701	29	26	90%	3	10%	3	0	0%	3	100%	10%	1.2
FISI 3001	56	40	71%	16	29%	20	4	23%	12	77%	22%	1.7
3002	45	38	84%	7	16%	9	2	27%	5	73%	12%	1.4
INGL 3101	85	74	87%	11	13%	15	3	31%	8	69%	90%	1.3
MATE 3021	67	42	63%	25	37%	43	12	47%	13	53%	20%	2
3022	47	37	79%	10	21%	17	4	42%	6	58%	13%	1.6
3053	11	4	36%	7	64%	11	2	25%	5	75%	47%	3.8
3111	88	60	68%	28	32%	50	15	54%	13	46%	14%	1.8
3112	77	63	82%	14	18%	23	6	44%	8	56%	10%	1.4
QUIM 3025	22	12	55%	10	45%	17	7	76%	3	24%	11%	2
3120	57	43	75%	14	25%	23	5	37%	9	63%	15%	1.7
3122	49	35	71%	14	29%	29	7	51%	7	49%	14%	1.8
3123	57	53	93%	4	7%	24	1	17%	3	83%	6%	1.5
3131	80	45	56%	35	44%	62	17	50%	18	50%	22%	2.3
3132	72	47	65%	25	35%	44	9	36%	16	64%	22%	2.1
3133	89	69	78%	20	22%	32	10	49%	10	51%	12%	1.5
3134	72	58	81%	14	19%	20	3	24%	11	76%	14%	1.5
4041	7	4	57%	3	43%	5	1	22%	2	78%	35%	2.7
4042	6	4	67%	2	33%	3	1	33%	1	67%	24%	2
4065	19	18	95%	1	5%	2	1	75%	0	25%	2%	1.1
4101	7	5	71%	2	29%	2	0	20%	2	80%	20%	1.7
SICI 3007	50	43	86%	7	14%	10	2	29%	5	71%	10%	1.3

Organic Chemistry II

Total of Students in Cohort	Satisfactory Outcomes (A, B, C) On First Attept		Unsatisfactory Outcomes (D, F, W, I) On First Attept		No. of Times Course was Repeated	Of the student who repeated the course, percentage who eventually approved the course satisfactorily				% of students who couldn't pass the course	index of course efficiency
	Number	% of Total	Number	% of Total		Satisfactorily completed course in more than one attempt		Unable to complete course satisfactorily in more than one attempt			
						Number	% of Unsat	Number	% of Unsat		
109	71	65%	38	35%	71	23	61%	15	39%	14%	1.9

Total number of times course was taken by cohort

Organic Chemistry II

Cohort Size: 109

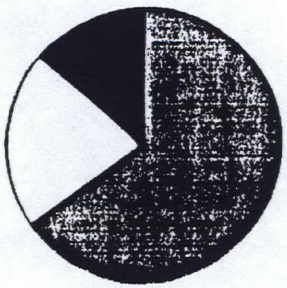
(first year enrollment of cohort 1984-86)

Percent of students in the cohort who approved course satisfactorily

Satisfactory approval on first attempt (A,B or C) 71 out of 109: 65%

Satisfactory approval course after more than one attempt (A, B or C) 23 out of 109: 21%

Fail to approve course satisfactorily (D, F, W or I) 15 out of 109: 14%



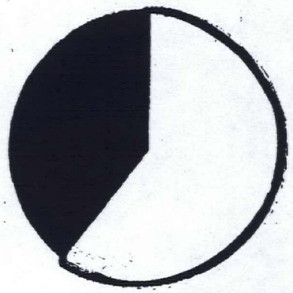
Number of times students who failed repeated the course: 71

Total number of times course was taken by cohort: 109 + 71 = 180

Of the students who repeated the course, percentage who eventually approved the course satisfactorily

Successful Repeats of D,F,W,I 23 out of 38 : 61%

Unable to Succcessfully Repeat Class 15 out of 38: 39%



Index of Course Efficiency (Average number of times a course must be taken to approve it successfully. A value of one (1) is ideal efficiency.) = 1.9

$$ICE = \frac{\text{Total number of times course was attempted}}{\text{Number of students who approved course satisfactorily}} \quad \frac{180}{94} = 1.9$$

Data on Problem Courses:
"Gate-Keeper" and "Bottle-neck" Courses
Index of Course Efficiency

							Results for Students With D, F, W, I on 1st Attempt					
Biology 1991 Cohort n=14 Course Codes	Total Enrollment 1991-97	Satisfactory Outcomes (A, B, C) On First Attempt		Unsatisfactory Outcomes (D, F, W, I) On First Attempt		No. of Times Unsatisfactory Class Was	Successful Repeat of D, F, W, I		Students Unable To Successfully Repeat Class		Unable to Repeat with A, B, C % of Total	Index of Course Efficiency (1.0 Ideal)
		Number	% of Total	Number	% of Total	Repeated	Number	% of Unsatisfactory	Number	% of Unsatisfactory		"I.C.E."
FISI 3011	26	22	85%	4	15%	4	3	75%	1	25%	4%	1.1
3012	22	18	82%	4	18%	2	2	50%	2	50%	9%	1.2
MATE 3052	29	22	76%	7	24%	5	5	71%	2	29%	7%	1.2
3053	27	16	59%	11	41%	10	4	36%	7	64%	26%	1.3
3171	33	26	79%	7	21%	5	3	43%	4	57%	12%	1.9
QUIM 3121	**23**	**19**	**83%**	**4**	**17%**	**4**	**4**	**100%**	**0**	**0%**	**0%**	**1.3**
3122	22	12	55%	10	45%	8	4	40%	6	60%	27%	1.2
3131	36	14	39%	22	61%	15	10	45%	12	55%	33%	1.9
3132	27	20	74%	7	26%	3	2	29%	5	71%	19%	2.1
3133	36	15	42%	21	58%	13	13	62%	8	38%	22%	1.8

							Results for Students With D, F, W, I on 1st Attempt					
Chemistry 1991 Cohort n=14 Course Codes	Total Enrollment 1991-97	Satisfactory Outcomes (A, B, C) On First Attempt		Unsatisfactory Outcomes (D, F, W, I) On First Attempt		No. of Times Unsatisfactory Class Was	Successful Repeat of D, F, W, I		Students Unable To Successfully Repeat Class		Unable to Repeat with A, B, C % of Total	Index of Course Efficiency (1.0 Ideal)
		Number	% of Total	Number	% of Total	Repeated	Number	% of Unsatisfactory	Number	% of Unsatisfactory		"I.C.E."
BIOL 3001	10	5	50%	5	50%	1	1	20%	4	80%	40%	1.8
3012	11	7	64%	4	36%	1	1	25%	3	75%	27%	1.5
MATE 3052	10	6	60%	4	40%	4	3	75%	1	25%	10%	1.6
3053	10	4	40%	6	60%	2	0	0%	6	100%	60%	3.0
QUIM 3121	**10**	**6**	**60%**	**4**	**40%**	**4**	**1**	**25%**	**3**	**75%**	**30%**	**2.0**
3122	9	5	56%	4	44%	3	2	50%	2	50%	22%	1.7
3123	9	6	67%	3	33%	2	2	67%	1	33%	11%	1.4
3131	14	8	57%	6	43%	4	3	50%	3	50%	21%	1.8
3132	11	8	73%	3	27%	2	2	67%	1	33%	9%	1.3
3133	14	10	71%	4	29%	2	2	50%	2	50%	14%	1.3
3134	11	8	73%	3	27%	2	2	67%	1	33%	9%	1.2

Comparison of ICE Number for Two Different Cohorts
Per PR-LSAMP Institution

Institution	Number of SMET Courses by ICE Category (1983-86 Cohort)	Number of SMET Courses By ICE Category (1991 Cohort)
Institution 1	ICE 1.0 - 1.9 = 3 courses ICE 2.0 – 2.9 = 4 courses ICE 3.0 – 3.9 = 4 courses ICE 4.0+ = 4 courses	ICE 1.0 – 1.9 = 5 courses ICE 2.0 – 2.9 = 8 courses ICE 3.0 – 3.9 = 1 course ICE 4.0+ = 1 course
Institution 2	ICE 1.0 - 1.9 = 0 course ICE 2.0 – 2.9 = 8 courses ICE 3.0 – 3.9 = 2 courses ICE 4.0+ = 1 course	ICE 1.0 - 1.9 = 10 courses ICE 2.0 – 2.9 = 3 courses ICE 3.0 – 3.9 = 1 course ICE 4.0+ = 0 course
Institution 3 (Engineering majors)	ICE 1.0 - 1.9 = 11 courses ICE 2.0 – 2.9 = 7 courses ICE 3.0 – 3.9 = 1 course ICE 4.0+ = 0 course	ICE 1.0 - 1.9 = 20 courses ICE 2.0 – 2.9 = 0 course ICE 3.0 – 3.9 = 0 course ICE 4.0+ = 0 course
Institution 3 (Science majors)	ICE 1.0 - 1.9 = 6 courses ICE 2.0 – 2.9 = 7 courses ICE 3.0 – 3.9 = 3 courses ICE 4.0+ = 0 course	ICE 1.0 - 1.9 = 15 courses ICE 2.0 – 2.9 = 1 course ICE 3.0 – 3.9 = 0 course ICE 4.0+ = 0 course
Institution 4	ICE 1.0 - 1.9 = 7 courses ICE 2.0 – 2.9 = 3 courses ICE 3.0 – 3.9 = 0 course ICE 4.0+ = 0 course	ICE 1.0 - 1.9 = 10 courses ICE 2.0 – 2.9 = 0 course ICE 3.0 – 3.9 = 0 course ICE 4.0+ = 0 course
Institution 5	ICE 1.0 - 1.9 = 6 courses ICE 2.0 – 2.9 = 3 courses ICE 3.0 – 3.9 = 0 course ICE 4.0+ = 0 course	ICE 1.0 - 1.9 = 9 courses ICE 2.0 – 2.9 = 0 course ICE 3.0 – 3.9 = 0 course ICE 4.0+ = 0 course
Institution 6	ICE 1.0 - 1.9 = 3 courses ICE 2.0 – 2.9 = 1 course ICE 3.0 – 3.9 = 1 course ICE 4.0+ = 0 course	ICE 1.0 - 1.9 = 1 course ICE 2.0 – 2.9 = 6 courses ICE 3.0 – 3.9 = 0 course ICE 4.0+ = 1 course

These are the SMET courses in which the cohort encountered the most difficulty in obtaining a satisfactory grade. Therefore, number of courses vary per cohort.

Institution 1
Comparison of ICE Numbers for Most Difficult SMET Courses
Cohorts Entering 1983-86 and Cohort Entering in 1991

SMET Course	ICE Number 1983-86 Cohort	ICE Number 1991 Cohort
BIOL 3012	1.8	1.4
BIOL 3019	2.1	1.3
BIOL 3115	2.5	1.5
BIOL 3305	1.9	2.6
BIOL 3420	1.7	1.4
MATE 3018	3.2	2.2
MATE 3061	4.1	3.1
MATE 3062	2.1	2.2
MATE 3081	4.0	2.1
MATE 3082	4.3	5.8
CHEM 3001	3.5	2.3
CHEM 3002	3.4	2.2
CHEM 3031	2.8	2.4
CHEM 4041	5.6	2.4
CHEM 4042	3.3	1.6

Institution 2
Comparison of ICE Numbers for Most Difficult SMET Courses
Cohorts Entering 1983-85 and Cohort Entering in 1991

SMET Course	ICE Number 1983-85 Cohort	ICE Number 1991 Cohort
BIOL 222	2.3	1.9
FISI 211	3.5	3.5
FISI 212	2.3	1.8
MATE 141	2.3	1.8
MATE 271	2.4	2.0
MATE 272	2.3	1.6
CHEM 201	2.1	1.2
CHEM 202	2.3	1.3
CHEM 231	5.2	1.6
CHEM 232	3.9	1.7
CHEM 421	2.2	2.5

Course Codes for Institution #1

BIOL 3012 – Modern Biology II
BIOL 3019 – Developmental Biology
BIOL 3115 – General Ecology
BIOL 3305 – Genetics
BIOL 3420 – General Zoology
MATE 3018 – Pre-Calculus and Analytical Geometry
MATE 3061 – Calculus I
MATE 3062 – Calculus II
MATE 3081 – Computer Programming I
MATE 3082 – Computer Programming II
CHEM 3001 – General Chemistry I
CHEM 3002 – General Chemistry II
CHEM 3031 – Organic Chemistry
CHEM 4041 – Physical Chemistry I
CHEM 4042 – Physical Chemistry II

Course Codes for Institution #2

BIOL 222 – Botany
FISI 211 – General Physics I
FISI 212 – General Physics II
MATE 141 – Algebra and Trigonometry
MATE 271 – Calculus I
MATE 272 – Calculus II
CHEM 201 – Organic Chemistry Lab I
CHEM 202 – Organic Chemistry Lab II
CHEM 231 – Organic Chemistry I
CHEM 232 – Organic Chemistry II
CHEM 421 – Physical Chemistry I