CAPÍTULO I   NUMERIC AND SYMBOLIC REASONING ASSESSMENT IN FRESHMAN MATHEMATICS COURSES

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ABSTRACT

Universidad de las Américas Puebla (UDLAP) is a Mexican prívate institution of higher learning. Since 1959, the Commission on Colleges of the Southern Association of Colleges and Schools (SACS) has accredited UDLAP in the United States. SACS comprehensive standard 3.5.1 states: "the institution identifies college-level general education competencies and the extent to which graduates have attained them". Therefore UDLAP had to clearly define its college-level general education competencies, and develop an assessment plan to learn about the extent to which graduates have attained UDLAP's college-level general education competencies as well as to enhance student learning and development of these competencies. As a result, UDLAP's General Education Committee identified the following competency areas: Written and Oral Communication in Spanish and English, Critical Thinking, Information Technology Literacy, and General Studies and Culture. Competencies from every area were clearly identified as well, including for the competency area of General Studies and Culture that UDLAP graduates will have an understanding of how knowledge is acquired and applied through the intellectual traditions of the arts, humanities, or social sciences; engineering or natural sciences; and business or economic sciences. As part of UDLAP's General Education Curriculum our students have to take three General Studies courses (3 credits each), one from each school (School of Engineering and Sciences, School of Business and Economy, and School of Social Sciences, Arts, and Humanities). In particular for the School of Engineering and Sciences this course is a Mathematics course, which has to focus on developing numeric and symbolic reasoning skills, and students select from a list of approved General Studies courses. Development of the Mathematics Assessment Plan consisted of three major parts: determining UDLAP's expectations; determining timing, identifying cohort(s), and assigning responsibilities; and interpreting and sharing results to enhance general education effectiveness.

Particular competencies (and expected outcomes) for the Mathematics courses were defined following SUNY at Geneseo as follows: Symbolization (ability to convert a problem into a setting using symbolic terminology), Relationships (ability to connect quantities and find relationships among symbolic quantities),

Formulation (ability to construct an appropriate symbolic framework), Analysis (ability to carry out algorithmic and logical procedures to resolution), and Interpretation (ability to draw valid conclusions from numeric/symbolic evidence). The Mathematics Committee chose to use rubrics as primary means of assessment to evaluate representative samples of student work (individual and group written and oral work products including quizzes, exams, homework, presentations, problem solving exercises) as well as teacher written and oral work products (presentations, problem solving exercises). Once students are assessed in a pre-test to determine his or her skill levels in the five chosen competencies, guided practice and training (both in the course and related problem solving sessions) is provided to every student. Students are required to reach a level of mastery (in a post-test) as measured by an average of meeting the expectations of the Numeric and Symbolic Reasoning Rubric. Up to date more than 300 students and 7 teachers have participated. The majority of the students have shown weakness in one or more of the targeted numeric and symbolic reasoning skill competencies.

1.1 BACKGROUND

Universidad de las Américas Puebla (UDLAP) is a Mexican private institution of higher learning. Since 1959, the Commission on Colleges of the Southern Association of Colleges and Schools (SACS) has accredited UDLAP in the United States. SACS comprehensive standard 3.5.1 states: "The institution identifies college-level general education competencies and the extent to which graduates have attained them". Therefore UDLAP had to clearly define its college-level general education competencies, and develop an assessment plan to learn about the extent to which graduates have attained UDLAP's college-level general education competencies as well as to enhance student learning and development of these competencies.

UDLAP's general education reflects our mission, vision and undergraduate profile[35]. UDLAP attempts to cultivate the knowledge, skills, values, and habits of mind that will allow our graduates to lead personally enriching and socially responsible lives as successful twenty-first century citizens of complex, changing, diverse, and interconnected local, national, and worldwide communities. The

undergraduate major is dedicated to provide thorough grounding in one particular subject while UDLAP general education curriculum is designed in order that our students discover new competences in themselves and reveal another level of existence that had been hidden from them. Thus, the general education experience is intended to enhance integral formation of the "whole student".

UDLAP general education requirements introduce students to a broad range of fields and areas of study in the *General Studies* and *General Culture* requirements. Also help students build an intellectual foundation for future pursuits through the Spanish, foreign language, and information technology requirements. Furthermore, UDLAP's Quality Enhancement Plan: *Enhancing Critical Thinking Skills in Our Undergraduate Students* is an integral part of our general education curriculum, as well as the community service project required for every UDLAP graduate[35].

UDLAP has established a general education curriculum for undergraduate students regardless of their major to assist them in acquiring the traits valued by UDLAP. The general education requirements (31.5 credits) for the undergraduate programs are published in *The Institutional Catalog* and include since fall 2006 the following:

• Spanish: two consecutive courses (3 credits each) regarding writing and oral communication in Spanish *(Thought and Language* and *Writing in the Professions* courses preferable), in the first three semesters of the program. Majors should further develop writing and oral communication skills of students throughout their programs;

• Foreign Language: three English courses (3.5 credits each) or a single foreign language (if proficient in English) in the first four semesters of the program. Majors should make use of English and further develop student knowledge and abilities throughout their programs;

• Information Technology: one course (3 credits) related to information technology *(Information Culture* course preferable) between the third and sixth semester of the program;

• General Studies: three courses (3 credits each), one from each school (School of Engineering and Sciences, School of Business and Economy,

and School of Social Sciences, Arts, and Humanities) from a list of approved general studies courses. These three courses could be taken in any semester of a program but preferably not in the same semester;

- General Culture: 3 credits that can be fulfilled with courses, workshops, and/or other Co-Curricular activities (approved by the Council of Deans); these could be taken in any semester of a program.

The faculty of all schools at UDLAP has incorporated these requirements into their degree plans. Many degrees require additional work in these areas or require the student to take specific courses to fulfill the requirements.

As a result of all of the above, the General Education Committee clearly identified the following competency areas and competencies (or expected outcomes, O) from every area:

UDLAP's General Education Competency Areas and Competencies:

1. Competency Area: Written and Oral Communication in Spanish

≠ O1: UDLAP graduates will be able to communicate effectively in oral and written Spanish in specific situations, which may include academic, professional, or civic situations.

≠ O2: UDLAP graduates will be able to generate a written or oral presentation that accommodates audience needs and exhibits mastery of basic communication skills.

2. Competency Area: English

≠ O3: UDLAP graduates will be able to communicate effectively in oral and written English in academic and professional situations.

3. Competency Area: Critical Thinking

≠ O4: UDLAP graduates will be able to improve the quality of their thinking by skillfully analyzing, assessing, and reconstructing it, taking charge of the structures inherent in thinking and imposing intellectual standards upon them, including the following dimensions: Intellectual Deliberations, Moral Dispositions, and Metacognitive and Learning Skills.

4. Competency Area: Information Technology Literacy

≠ O5: UDLAP graduates will be able to identify, locate, and make effective

use of information from various electronic and print sources, as well as from modern information resources and supporting technologies, with attention to the standards of academic honesty.

5. Competency Area: General Studies and Culture

≠ O6: UDLAP graduates will have an understanding of how knowledge is acquired and applied through the intellectual traditions of the arts, humanities, or social sciences; engineering or natural sciences; and business or economic sciences.

≠ O7: UDLAP graduates will have a knowledge of and respect for the inherent diversity of peoples and ideas and for the principles and practices of ethical behaviors and moral values.

≠ O8: UDLAP graduates will demonstrate capacity for a worthy use of leisure by valuing participation in co-curricular activities such as fine and performing arts; conferences, short courses and workshops; sports and other physical activities.

The GE Committee compared the identified UDLAP's general education competencies and learning outcomes with college-level general education competencies of several top-level universities and colleges accredited by SACS (Florida State University, Georgia Institute of Technology, Georgia Southern University, Louisiana State University, Nicholls State University, North Carolina State University, Southeastern Louisiana University, Texas A&M University, University of Florida, University of North Carolina, University of Tennessee, University of Texas, University of Virginia, Virginia Tech, West Texas A&M University, among others), as well as with prestigious universities and colleges accredited by other agencies (Alverno College, Harvard University, Montgomery College, Princeton University, Stanford University, State University of New York College at Geneseo, among others[3, 13-16, 18-19, 23-25, 27, 30-34, 36-42, 44]) prior to its submission the Academic Council. Then after being ratified by the Academic Council, approval from UDLAP's Governing Board was obtained.

The goal of UDLAP's General Education Committee is that after implementation of plans, assessment will become a collective means whereby

colleagues discover the fit between institutional or programmatic expectations for student achievement and patterns of actual student achievement. Assessment of general education competencies, then, will become a lens through which UDLAP assesses itself through its students' work. Then after several semesters of implementation and motivated by institutional curiosity, assessment of GE competencies will become, over time, an organic process of discovering how and what and which students learn. An institutional commitment to assessment (a curiosity about learning) will eventually transform UDLAP into a true learning community that raises questions about student learning and development[2, 4-7, 20, 21, 43].

1.2 STRATEGY

UDLAP's general education assessment has been undertaken for purposes of accountability and improvement of the overall program. The intent of these assessment plans is to measure the effects of UDLAP's general education curriculum on student progress and to provide feedback on the performance of general education curriculum. This will provide faculty and staff several means to evaluate and improve the general education areas in a systematic and effective manner. UDLAP's general education competencies are broad-based and appropriate to the mission and purpose of our University. Therefore, examining student progress in these competencies will identify effectiveness of the general education curriculum. The identified UDLAP's general education competency areas (e.g. Spanish, English, Critical Thinking, etc.) were utilized to generate sub-committees that developed a particular assessment plan for every area. Plans are intended to promote institutional curiosity that seek answers to questions about which students learn, what they learn, how well they learn, and when they learn, and explore how pedagogies and educational experiences develop and foster student learning of general education competencies[4-7, 20-21, 43].

As part of UDLAP's General Education Curriculum our students have to take three General Studies courses (3 credits each), one from each school (School of Engineering and Sciences, School of Business and Economy, and School of Social Sciences, Arts, and Humanities). In particular for the School of Engineering and Sciences this course is a Mathematics course, which has to focus on developing numeric and symbolic reasoning skills, and students select from a list of

approved General Studies courses. Development of the Mathematics Assessment Plan consisted of three major parts: determining UDLAP's expectations; determining timing, identifying cohort(s), and assigning responsibilities; and interpreting and sharing results to enhance general education effectiveness[20, 21]. Five competencies (and expected outcomes) for the GE mathematics courses were defined following State University of New York (SUNY) College at Geneseo[33] as follows:

01	*Symbolization*	ability to convert a problem into a setting using symbolic terminology
02	*Relationships*	ability to connect quantities and find relationships among symbolic quantities
03	*Formulation*	ability to construct an appropriate symbolic framework
04	*Analysis*	ability to carry out algorithmic and logical procedures to resolution
05	*Interpretation*	ability to draw valid conclusions from numeric/symbolic evidence

The Mathematics Committee will submit their assessment reports to the General Education Committee. The reports will include a description of improvements/actions taken based on previous assessments; results of the current-year assessment; the number and percentage of students assessed; a description of how current assessment results will be used for improvement. GE competency areas will conduct assessment on a three-year cycle.

1.3 VALIDITY AND RELIABILITY

The Mathematics Committee chose to use SUNY at Geneseo Numeric and Symbolic Reasoning Rubric[32] (Figure 1) as primary means of assessment to evaluate representative samples of student work (individual and group written and oral work products including quizzes, exams, homework, presentations, problem solving exercises) as well as teacher written and oral work products (presentations, problem solving exercises). This method places responsibility for assessment at the committee level and is consistent with the current structure of general education at UDLAP. In some cases the rubrics will be used by the Mathematics Assessment Committee to evaluate representative samples of student work (as in this paper); in other cases they will be used in primary trait analyses conducted by individual faculty members.

Numeric and Symbolic Reasoning Rubric

	Symbolization The ability to convert a problem into a setting using symbolic terminology	Relationships The ability to connect quantities and find relationships among symbolic quantities	Formulation The ability to construct an appropriate symbolic framework	Analysis The ability to carry out algorithmic and logical procedures to resolution	Interpretation The ability to draw valid conclusions from numeric/symbolic evidence
4. Exceeding	The student displayed a clear command of the area's terminology and notation by describing verbally all the relevant quantities or variables in the problem and labeling each quantity in appropriate mathematical or symbolic terms consistent with standard usage.	The student verbally justified the introduction of a complete set of relationships among the symbolic forms, including auxiliary elements; provided multiple visual representations of various cases that were complete and accurate.	The student structured the problem in a novel way, viewing familiar aspects from a new perspective.	The student used a creative method leading to an elegant solution; carried out a logical sequence of algorithms and procedures; used symbolic operational rules flawlessly; performed computational steps with precision.	The student drew valid wellstated and well-justified conclusions from the symbolic/numeric solution; demonstrated insight in expressing the meaning of the symbolic solution in the context of the original problem.
3. Meeting	The student displayed a sufficient command of the terminology and notation by labeling all the relevant quantities in the problem; used the area's mathematical/ symbolic terminology correctly.	The student listed a complete set of relationships among the symbolic forms, perhaps introducing additional elements; provided a complete, accurate visual representation which revealed key relationships.	The student identified a relevant conventional framework for the problem and determined all the pertinent parameters.	The student made a minor computational error, but the mathematical/operational procedures used led to an essentially correct solution.	The student drew valid clearlystated and reasonably-justified conclusions from the symbolic/numeric solution; clearly expressed the meaning of the symbolic solution in the context of the original problem.
2. Approaching	The student failed to identify an important quantity or variable in the problem; was inconsistent in the use of the mathematical/symbolic terminology or notation.	The student made progress finding relationships but missed a significant connection; introduced a visual representation that was incomplete or inaccurate.	The student was aware of a relevant framework but failed to consider an important aspect of the structure.	The student made a major/basic computational error, but the mathematical/ operational procedures used led to a partially correct solution.	The student drew valid but poorly stated conclusions from the symbolic/numeric solution; provided a weak attempt to express the meaning of the symbolic solution in the context of the original problem.
1 Not Meeting	The student failed to identify any important quantities or variables in the problem; introduced mathematical or symbolic representations which were incorrect; consistently used mathematical/symbolic terminology incorrectly.	The student used irrelevant information in trying to set up the problem; relied on visual representations that were misleading; neglected fundamental connections and relationships.	The student was unable to focus the work toward a relevant structure; seemed to be unaware of a framework for the problem.	The student tried to use an inappropriate algorithm or method of solution or was unable to follow an algorithm or mathematical procedure to completion; made computational errors serious enough to flaw the solution.	The student seemed unaware of the significance of the symbolic/numeric solution; drew a conclusion unsubstantiated by the results obtained.
	Convert	connect	Construct	carry out	conclude

Figure 1. State University of New York (SUNY) College at Geneseo Numeric and Symbolic Rubric[32]

Rubrics are reliable only when applied consistently by different individual raters. To ensure that rubrics will be applied consistently within particular the Mathematics area, UDLAP conducted a workshop every semester for those faculty actively involved in assessing general education outcomes. In these workshops, faculty applied the chosen rubric to samples of student work and discussed the results. Together, practice and discussion narrowed the range of variation among individual raters sufficiently to ensure reliable and valid scoring[33].

1.4 ASSESSMENT OF ASSESSMENT

The general education assessment program will be evaluated on a yearly basis and at the end of each three-year cycle. At the end of each year a subcommittee of the General Education Committee will meet with those general education faculty who have conducted assessment in their general education areas that year. The discussion will focus on any problems encountered in implementing assessment plans, possible improvements in the process, and any useful information gained from the assessment. In addition, student responses to the general education questions on the annual Senior Survey will be examined to determine whether the students have perceived improvements. At the end of the entire three-year cycle, all faculty teaching general education courses will be surveyed to evaluate their views of the assessment process and their perceptions of improvement in general education.

1.5 STUDIED COURSE

Because the Numeric and Symbolic Reasoning requirement is met by several Mathematics courses at UDLAP, instead of administering a standardized test, faculty who teach courses fulfilling this requirement will:

a. select several student samples of their classroom assignments;
b. use the chosen scoring rubric, in the form of a primary trait analysis;
c. compile aggregated student scores using the rubric; and
d. analyze the students' scores and determine whether changes in the classroom would help students improve their Numeric and Symbolic skills.

At the end of the each year the Mathematics Committee will ask each instructor in a block of the courses (rotating on a three-year basis) to provide evidence that appropriate assessment is taking place. The weight of trying to

assess too many learning outcomes as an institution that is beginning its commitment may unduly tax faculty and professional staff, who need to determine how their culture will integrate the process of learning about student learning into institutional rhythms and practices. Thus, our approach initially involves the assessment of very few outcomes per area[20, 21].

In order to start with the process of modification of every general education course of the area of mathematics, it was decided to change a single course during the semester of Fall 2008, in such a way that it served as pilot before modifying other courses. The selected course was Mathematics for Business (MA-117). This is a required course for first semester students at the School of Business and Economy. MA-117 is first of two required mathematics courses for these students. Many students in MA-117 have difficulty adjusting to the expectations, fully understanding the material, and achieving good grades. Too many students either change their majors away from business and economy or experience a frustrating period of time before establishing a successful academic path. We believe a major cause is often students' inadequately developed mathematical intuition as well as numeric and symbolic skills set.

During Fall 2008, around 350 students and 7 teachers participated in MA-117 redesign. A community of practice was formed with the teachers, and 4 months before the semester started they attended workshops related to *How People Learn* framework; assessment; active, collaborative, and cooperative learning; and research methods in mathematics; as well as the one related to rubric implementation[1-2, 4-9, 10-12, 17, 20-22, 26, 28-29, 43]. Several classroom activities, assignments, quizzes, homework, tests, and rubrics were designed by the community of practice during this four months[4]. Further, for the first time in MA-117, attendance to the problem sessions was mandatory and student work in these sessions had an impact on course final grade. An additional 150 students and 5 teachers are currently being tested during the Spring 2009 semester.

Once students were assessed in a pre-test (during the first week of classes) to determine his or her skill levels in the five chosen competencies, guided practice and training (both in the course and related problem solving sessions) was provided to every student. Students were required to reach a level of mastery (in a

post-test, administered in the last week of the semester) as measured by an average of meeting the expectations of the Numeric and Symbolic Reasoning Rubric[32] (Figure 1). Furthermore, each teacher was asked to present at least a classroom assignment and a test every month, the associated scoring rubrics, and aggregated student scores; an analysis of the data; and any changes planned for the enhancement of student numeric and symbolic skills. The Mathematics Committee reviewed the materials forwarded from the teachers. Faculty involvement in closing the loop at the classroom level is one of the key benefits of this classroom-based assessment model. An exit survey regarding the five competencies was also administered in which students valued the importance of each competency and evaluated his/her progress in achieving these competencies.

The approach described above differs from previous assessment methods at the University. MA-117 had been a course primarily knowledge-centered; course evaluation was primarily performed using summative assessments: three mid-term exams (each accounted 20% of the final grade) and a final exam (worth 25% of the final grade), while the remaining 15% of the final grade was assigned by every teacher, but most of them allocated this percentage taking into account only if the student handed its homework. Therefore formative assessments were scarce, students worked individually and only few times the course was learner-, assessment-, or community-centered[9, 26].

1.6 RESULTS AND DISCUSSION

Mean student achievement of the targeted numeric and symbolic reasoning skills can be seen in Figure 2. In every case there is a significant difference ($p < 0.05$) between results before and after the course (pre- *vs.* post-test) for every studied numeric and symbolic reasoning competency. Also there is a clear difference between student achievement of lower-level (symbolization and relationships) and higher-level (analysis or interpretation) competencies. In general, most of the students reached 'meeting' the expectations for the five competencies, however only for symbolization and relationships competencies 'exceeding' the expectations were found.
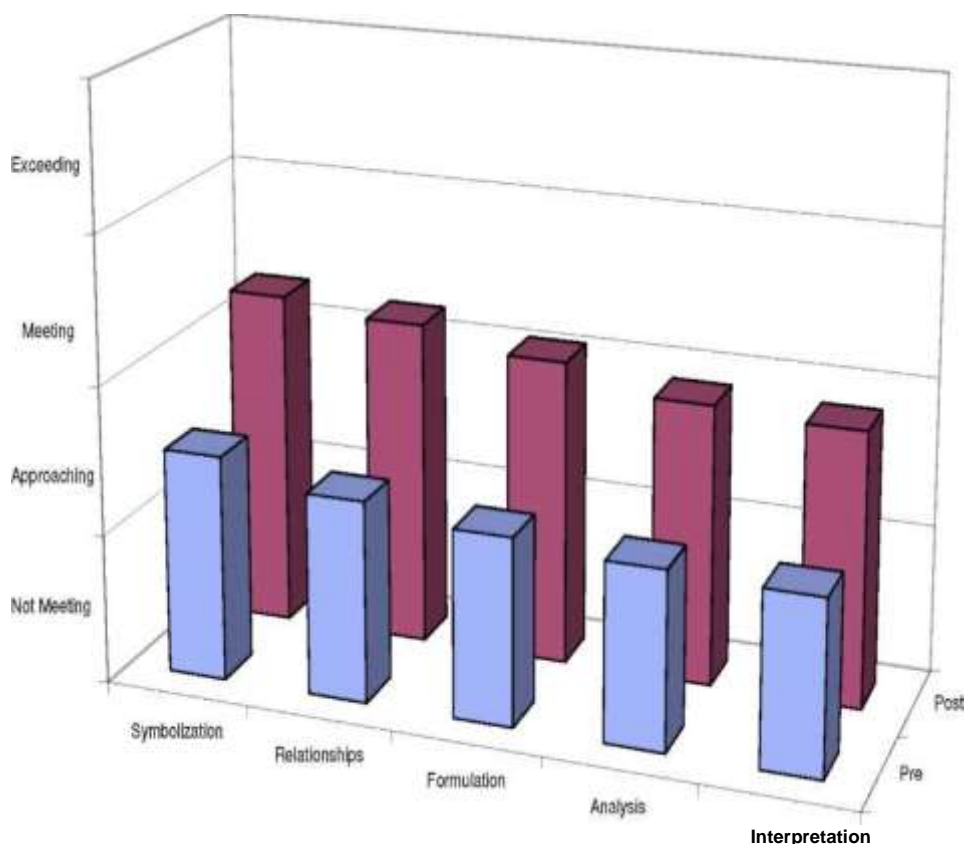
Figure 2. Pre- and post-test results assessed by SUNY at Geneseo Numeric and Symbolic Rubric[32].

The majority of the students have shown weakness in one or more of the targeted numeric and symbolic reasoning skills. Therefore, it is necessary to further develop in our freshman students the higher-level competencies, especially analysis and interpretation, i.e. their ability to carry out algorithmic and logical procedures to resolution, as well as to draw valid conclusions from numeric/symbolic evidence. As can be seen in Figure 3, the percentage of freshman students who exhibit difficulty with one or more of the five target competencies is quite high. This provides some validation to the professors' subjective impressions of poor numeric and symbolic reasoning skills among many of the incoming freshmen.
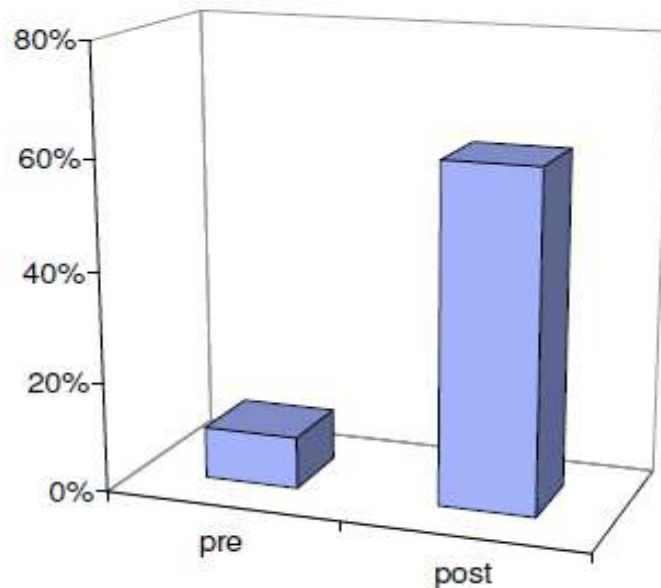
Figure 3. Percentage of students having at least 'meeting' the expectations in the five numeric and symbolic competencies assessed in the pre- and post-test by SUNY at Geneseo Numeric and Symbolic Rubric[32].

The SUNY at Geneseo Numeric and Symbolic Rubric32 (Figure 1) provides detailed information about the criteria for assessment and clear standards for judging whether students are exceeding, meeting, approaching, or not meeting the expected learning outcomes previously described in the five competencies for the GE mathematics courses. However we could average the constituent measures in order to provide a snapshot of students' performance relative to a more global measure such as student quantitative reasoning skills. A finer-grained measure of student learning can be seen in Figure 4; the values presented relate to the standards of success as follows: > 80 is exceeding, > 60 is meeting, > 40 is approaching, and < 20 is not meeting the expectations.

Their teacher gave students notification of the results of the pre-test. Because the pre-test covered the five areas mentioned above, in relaying the results to the students they were told whether or not they were 'meeting' an specific outcome. Thus a student may have been successful in symbolization and relationships, but not successful in formulation or analysis. If a student showed a deficiency in a competency area, then they were asked to attend problem solving sessions that would help him/her to solidify its understanding and improve their skills. These problem-solving sessions were scheduled at various time periods

throughout the week (including Saturdays). They were staffed and managed by more than 10 mathematics TA's. The students could walk into any of the scheduled sessions to work on various materials to help improve their skills in the needed area along with very individualized tutoring. Some teachers were very proactive in encouraging their students to attend more than one problem solving session to improve their numeric and symbolic reasoning skills while other instructors were not.
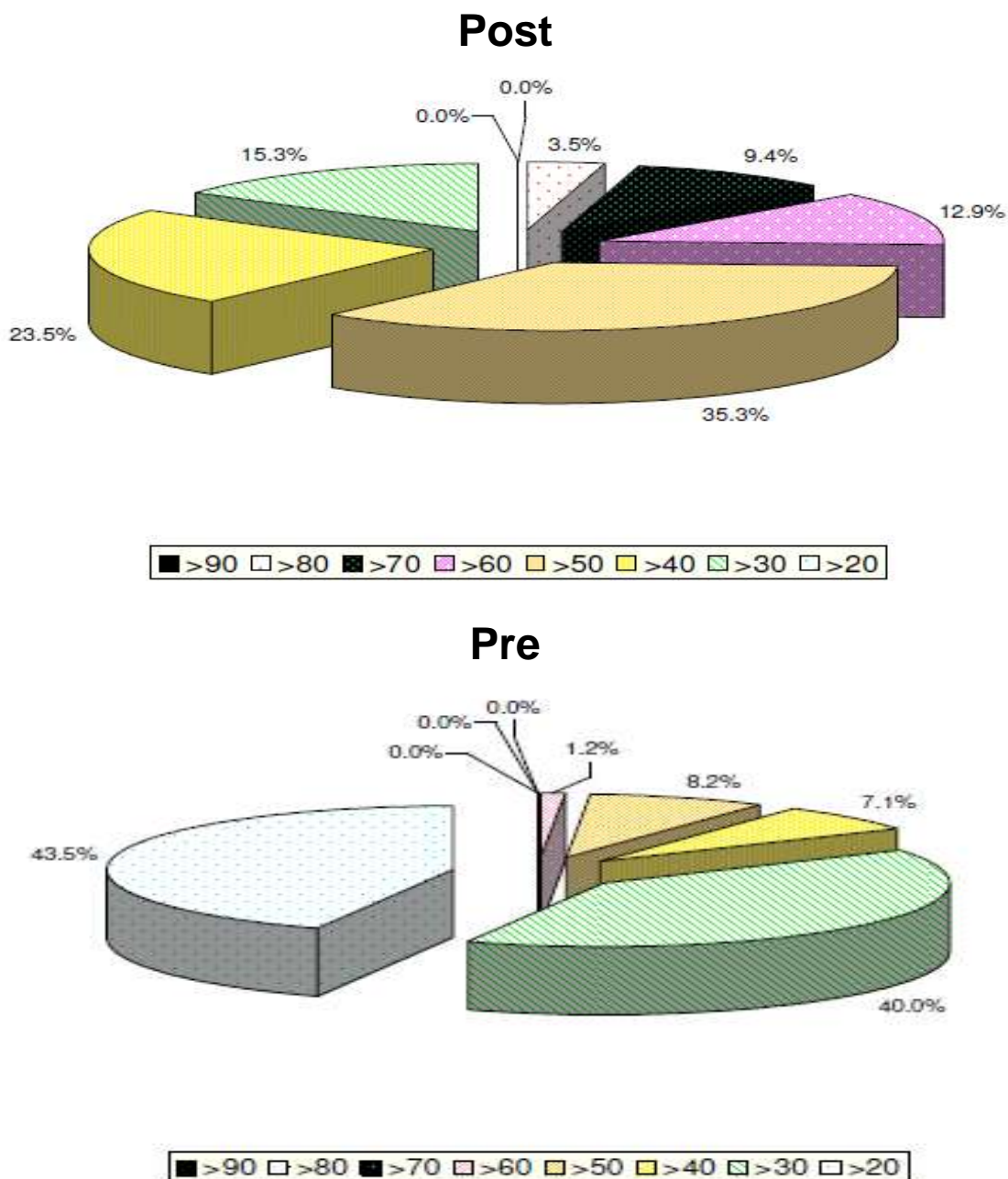
Post

>90 >80 >70 >60 >50 >40 >30 >20

Pre

>90 >80 >70 >60 >50 >40 >30 >20

Figure 4. Pre- and post-test results finer-grained assessed using SUNY at Geneseo Numeric and Symbolic Rubric.

Similar results as the ones in the post-test were obtained in the classroom assignments and tests assessed every month (data not shown). MA-117 teachers have to identify if, in fact, they provide sufficient educational opportunities inside and outside of the classroom to develop the desired outcomes they assert they teach or develop. Courses may be one means, but several other options exist. To assure that students have sufficient and various kinds of educational opportunities to learn or develop desired outcomes, the Mathematics Committee is currently engaged in curricular and co-curricular mapping.

UDLAP has to assure itself that it has translated its mission and purposes into its programs and services to more greatly assure that students have opportunities to learn and develop what our institution values. Without ample opportunities to reflect on and practice desired outcomes, students will likely not transfer, build upon, or deepen the learning and development of UDLAP's general education values[8]. Establishing baseline data for entry level students is enabling us to chart how well students learn and develop general education competencies over time; thus similar assessments are being carried out in the following required mathematics course for students from the School of Business and Economy at UDLAP. Assessing student learning over time will provide valuable information about how well students are progressing towards UDLAP's general education expectations in general, and the numeric and symbolic reasoning outcomes in particular.

An exit survey regarding the five competencies was also administered in which students valued the importance (without taking into account if he/she has achieved it or not) of each competency and evaluated his/her progress (without taking into account how important is for he/she) in achieving these competencies. MA-117 students highly value the five competencies and judge their importance greater than their progress in achieving them as can be seen in Table 1 and Figure 5.

On the other hand, students while assessing their own progress consider themselves in a higher level than the results when assessed using the SUNY at Geneseo Numeric and Symbolic Reasoning Rubric[32]. Interpretations of student achievement could then be linked to the kinds of learning experiences that do or do not promote UDLAP's outcomes. Interpreting students' performance or

achievement over time and sharing assessment results with students will enable UDLAP students to understand their strengths and weaknesses and to reflect on how they need to improve over the course of their remaining studies[8].

Table 1. Exit survey results*.

o1. Ability to convert a problem into a setting using symbolic terminology Importance: 4.45 ± 0.75 Progress: 3.63 ± 0.87 Different – greater importance than progress ($p < 0.05$)
o2. Ability to connect quantities and find relationships among symbolic quantities Importance: 4.45 ± 0.60 Progress: 3.88 ± 0.72 Different – greater importance than progress ($p < 0.05$)
o3. Ability to construct an appropriate symbolic framework Importance: 4.38 ± 0.77 Progress: 3.53 ± 0.72 Different – greater importance than progress ($p < 0.05$)
o4. Ability to carry out algorithmic and logical procedures to resolution Importance: 4.53 ± 0.75 Progress: 3.53 ± 0.96 Different – greater importance than progress ($p < 0.05$)
o5. Ability to draw valid conclusions from numeric/symbolic evidence Importance: 4.55 ± 0.68 Progress: 3.98 ± 0.83 Different – greater importance than progress ($p < 0.05$)

*Students judged the importance (without taking into account if he/she has achieved it or not) of each competency and evaluated his/her progress (without taking into account how important is for he/she) in achieving these five competencies. The scale for both evaluated parameters goes from 1 (none) to 5 (a lot).
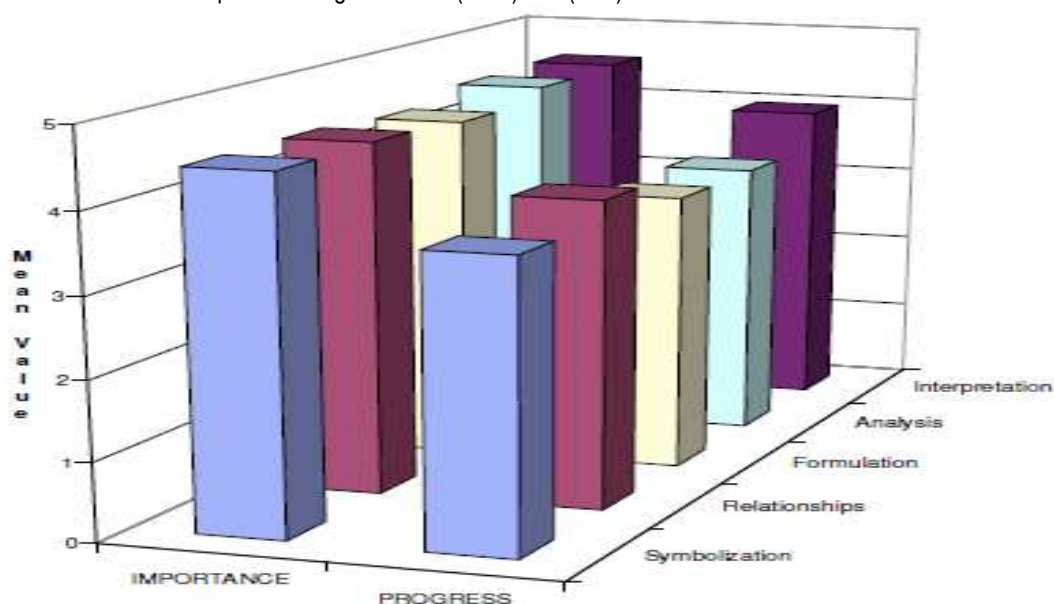

Figure 5. Exit survey results. Students judged the importance (without taking into account if he/she has achieved it or not) of each competency and evaluated his/her progress (without taking into account how important is for he/she) in achieving these five competencies. The scale for both evaluated parameters goes from 1 (none) to 5 (a lot).

If UDLAP aims to sustain its assessment efforts to improve continually the quality of education, it needs to develop channels of communication whereby it shares interpretations of students' results and incorporates recommended changes

into its budgeting, decision making, and strategic planning as these processes will likely need to respond to and support proposed changes. Assessment of general education is certain to fail if UDLAP does not develop channels that communicate assessment interpretations and proposed changes to its centers of institutional decision making, planning, and budgeting.

1.7 CONCLUSIONS

Our experience with the use of rubrics as primary means of assessment to evaluate representative samples of student work has taught us several things. First, the percentage of freshman students who exhibit difficulty with one or more of the five target competencies is quite high. This provides some validation to the professors' subjective impressions of poor mathematics skills among many of the incoming freshmen. Second, students are very unlikely to follow through with the problem solving sessions unless this activity is a required part of their course; voluntary participation produced low participation rates. Third, and most importantly, the use of SUNY at Geneseo Numeric and Symbolic Reasoning Rubric[32] produces measurable data of student performance in freshman mathematics courses and allows to easily track student improvement in the five target competencies. Examination of the effect of our approach on student retention rates is planned as one of the next steps of our study.