THE ASSESSMENT PROCESS

The main objective of this voluntary assessment of the program was to evaluate our existing curriculum relative to the Biotechnology and Biomedical Skills Standards developed in Phase I of the overall project. This evaluation would then be used to develop strategies to better align the skills possessed by graduates of the SPU Program in Biotechnology with the entry-level skills expected by industry seeking to hire those graduates. The basic process used was similar to that employed in evaluating the Biotechnology Specialist Program at Shoreline Community College (SCC). Skills project managers, who had facilitated in the SCC process, organized a training session for SPU faculty and administrators to explain the goals of the curriculum assessment and to suggest possible approaches that we might take to reach these goals in our own evaluation. SPU faculty participants then met regularly over a period of three months to plan and carry out the assessment process.

Each faculty participant was given specific responsibilities within the process: Dr. Fitch was placed in charge of the gap analysis procedure, Dr. Congdon dealt with areas of potential articulation between SPU and community college programs, and Dr. Ridgway served as primary facilitator of the assessment. All three contributed to the preparation of the final report presented here. The evaluation began with a review and discussion of the existing curriculum to identify the program's basic aims, activities, and modes of assessment. We next progressed to the gap analysis procedure (see Section II.3.a for a detailed description), first filling out the gap analysis matrix and then validating our findings against program descriptions, course syllabi, and the external review carried out by Dr. Arp in March of 2000. Finally, we used these evaluative tools to search for program strengths and weaknesses, to develop recommendations for improving the curriculum, and to identify possible areas for articulation.

Critical Functions and Key Activities	Where is this activity taught and practiced in the curriculum?	How is it taught and practiced?	How is it assessed?	Degree of emphasis in the curriculum?
A. Perform routine laboratory support work				
A1. Maintain laboratory and equipment	Covered directly in Molecular Biology (B4325), Cell Biology (B4352), Biochemistry 4361 and 4362 (C4361-2) and Quantitative Analysis (C3225)	Exposure to equipment processes, equipment details, and operating instructions occurs in lectures and labs. In B4325 biotechnology equipment (gel boxes, pipettors, power supplies, microcentrifuges, and pipette aids) is actually checked out to students for the quarter and must be checked in prior to receiving lab grades.	Students are given oral directions and watched closely by instructors, lab staff, and TAs when new equipment is introduced. Assessment is through lab reports and maintained lab notebooks (See Section C1)	MODERATE EMPHASIS
A2. Order and stock supplies	Currently not taught in any courses. Lab managers play this role along with help from undergraduate student assistants. Professors order supplies through lab staff.	Not specifically addressed in curriculum.	Not assessed	NOT COVERED
A3. Operate equipment	Covered directly in Molecular Biology (B4325), Cell Biology (B4352), Biochemistry (C4361-2) and Chemical Equilibrium and Analysis (C3225)	Exposure to equipment processes, equipment details, and operating instructions occurs in lectures and labs. Students do not repair equipment but are asked to trouble shoot. A student's success in lab is directly correlated to their ability to correctly operate equipment.	Students are given oral directions and watched closely by instructors, lab staff, and TAs as new equipment is introduced. Assessment is through lab reports and maintained lab notebooks (see Section C1)	MODERATE EMPHASIS
A4. Maintain biological stock cultures	Covered directly in Molecular Biology (B4325), and indirectly in Cell Biology (B4352), and Genetics (B3325)	Students keep their own bacterial stocks as well as generate transformed bacterial stocks in B4325. Students work in groups with established biological stocks in B4352 and B3325. Students also care for their own Drosophila stocks in B3325.	Maintenance of biological stocks is essential for success in B4325. Students must generate all their own bacterial stocks, maintain them throughout the quarter, and be able to extract DNA from their stocks. Without proper stock maintenance lab experiments would be unsuccessful. This is assessed through the keeping of the laboratory notebook and oral reporting.	HIGH EMPHASIS
A5. Clean and prepare items for lab	Specifically addressed in Chemical Equilibrium and Analysis (C3225) & Molecular Biology (B4325) Lab staff and helpers do much of this work. This is limited primarily to glassware and media preparation.	Students instructed as to proper cleaning and care of glassware and storage / disposal of reagents. The same is true regarding pathogens and hazardous materials.	Assessed through graded lab assignments in C3225 and B4325. Direct observation by instructors, lab staff, and TAs is also important for assessment in this area.	MODERATE EMPHASIS
A6. Prepare biological and/ or chemical materials	Emphasized in most Chemistry and Biology courses (esp. Quantitative and Instrumental Analysis (C3226), C3225, C4361-2, B3225, B4352 & B4325.) This is covered less in lower division courses.	Students are required to make their own molar, normal, and percent solutions following proper procedures. Instructors inform students of how to handle / dispose of hazardous materials.	Assessed both directly and indirectly by way of lab exercises and notebooks. In upper division labs, students are often required to prepare all their own solutions (e.g. B4325 and C4361-2)	VERY HIGH EMPHASIS

Critical Functions and Key Activities	Where is this activity taught and practiced in the curriculum?	How is it taught and practiced?	How is it assessed?	Degree of emphasis in the curriculum?
A7. Send, receive and distribute biological and chemical materials	Currently not taught. (This skill can be taught on the job, as shipping and receiving procedures are usually company specific. A specialized department often handles these functions.)	N/A	N/A	NOT COVERED
A8. Perform routine animal care duties	Currently not taught in any Biotechnology related classes. (Any animal care, purchasing, and/or disposal is carried out by lab staff in consultation with instructors. Instructors inform students of proper animal care protocols on a case-by-case basis.)	Not taught or practiced in any systematic way.	Not assessed	LOW EMPHASIS
A9. Communicate with co-workers to ensure quality laboratory work	All labs emphasize workplace communication. Many labs require lab work in pairs and exchange of information prior to documentation. The exchange of information is directly covered in B3325, B4352, & B4325. In B3325 & B4352 students work in pairs and report individually. In B4325 students work individually but must communicate their results with each other. Several experiments in all these classes require sharing class data.	Following lab protocols, giving attention to detail, providing accurate documentation, and exhibiting good behavior and communication are all expectations of upper division labs. It is taught through oral communication, e-mail postings to entire classes, lab "whiteboards" for posting information as well as thorough written lab reports and formal lab notebooks.	Assessment through lab reports, lab testing, group or team assignments and maintaining of lab notebooks. One on one observation in lab settings by instructors, lab staff, and TAs occurs.	VERY HIGH EMPHASIS
B. Assist with research & development				
B1. Perform assays and experiments	Assays and experiments are carried out in all Chemistry or Biology classes within the curriculum. In lower division courses (e.g. General Biology (B2101) and General Chemistry (C1211) protocols are provided. In other courses (e.g. Organic Chemistry (C2373), B4352, & B4325) more freedom is given to develop modifications to protocols.	Ranges from commercially prepared protocols - to student-designed experiments. Students use lab manuals to outline and document experimental protocols. They also troubleshoot problems as they arise. More advanced students carry out research projects involving controlled experimentation.	In most courses, lab assignments are received and graded by the instructor. These assignments may be submitted individually or included in lab notebooks. Research projects are supervised by faculty members or off-campus supervisors (e.g. internships.)	VERY HIGH EMPHASIS
B2. Assist in method development	Covered directly in Molecular Biology (B4325), and Biochemistry (C4362-3) where lab experiments are taught as quarter long projects.	These senior level labs require quarter long projects and do have written protocols that are followed fairly directly but occasionally need to be modified by the student due to previous results. At this point the students must engage in trouble shooting	Assessment occurs through one on one observation because a great deal of individualized instruction is necessary at these junctures. One on one communication with the students helps ensure success when methods need to be altered. Again,	MEDIUM EMPHASIS

Critical Functions and Key Activities	Where is this activity taught and practiced in the curriculum?	How is it taught and practiced?	How is it assessed?	Degree of emphasis in the curriculum?
		and method development. Students engaged in undergraduate research also actively investigate method development.	these alterations are kept in a continuously maintained lab notebook.	
B3. Investigate new technologies and methodologies	Covered directly in Molecular Biology (B4325) & Biochemistry (C4361-2-3) where lab experiments are taught as quarter long projects and where senior level presentations are made regarding new technologies.	These senior level labs and classes spend time investigating current technologies through research presentations (B4325 & C4363) and grant writing (B4325.) The labs also strive to stay as current as possible with new methodology. (See Section B2.) Also, investigation of new methodology and new technologies is expected in all undergraduate research projects.	Peer assessment of presentations, instructor assessment of presentations, and instructor grading of written work are all used in these classes. New methodologies used in the lab are also kept in a continuously maintained lab notebook.	MODERATE EMPHASIS
B4. Perform data analysis	All lab courses in Chemistry and Biology involve collection of data and analysis at some level of detail. Statistics (M1360) also covers statistical analyses.	Data analysis is systematically included in all courses especially those with lab components. Guidance is given in the collection of data, accuracy and precision of methods, statistical relevance, etc. Lab reports and notebooks must show evidence of data analysis, including error analyses.	Assessment includes lab quizzes, exams, grading of notebooks, lab presentations, and reports, etc.	VERY HIGH EMPHASIS
B5. Handle and/or maintain biological stock cultures	Covered directly in Molecular Biology (B4325), and indirectly in Cell Biology (B4352), and Genetics (B3325.) (see Section A4)	Students keep their own bacterial stocks as well as generate transformed bacterial stocks in B4325. Students work in groups with established biological stocks in B4352 and B3325. Students also care for their own Drosophila stocks in B3325.	Maintenance of biological stocks is essential for success in B4325. Students must generate their own bacterial stocks, maintain them throughout the term, and be able to extract DNA from these stocks. Without proper stock maintenance lab experiments would be unsuccessful. This is assessed through the keeping of the laboratory notebook.	HIGH EMPHASIS
B6. Troubleshoot experiments and equipment	Covered directly in Molecular (B4325) & Biochemistry (C4361-2) where lab experiments are taught as quarter long projects. (See Section A1)	These senior level labs, which require quarter long projects, have written protocols that are followed fairly directly, but they occasionally need to be modified by the student due to previous results. At this point the students must engage in trouble shooting of both protocols and instrumentation. When results vary from step one, troubleshooting must occur to get to step 2 for example.	One on one observation is necessary because a great deal of individualized instruction is necessary. One on one communication by the instructor, the lab staff and TAs help the students at these "trouble shooting" junctures. These lab protocol alterations ranging from minor to major are kept in a continuously maintained lab notebook.	MODERATE EMPHASIS

Critical Functions and Key Activities	Where is this activity taught and practiced in the curriculum?	How is it taught and practiced?	How is it assessed?	Degree of emphasis in the curriculum?
B7. Communicate results	All labs throughout the program emphasize the need for communicating results.	Results are communicated throughout the curriculum in a variety of ways ranging from oral lab reports, written term papers, written lab reports, (both formal and less formal,) and ranging from notes in a standard lab notebook to industry standard lab notebooks.	Assessment is through lab reports, lab testing, group or team assignments and maintained lab notebooks. One on one observation also occurs in lab setting.	VERY HIGH EMPHASIS
C. *Manufacture the product or provide the service*				
C1. Set up equipment for the production process	Covered indirectly in Molecular Biology (B4325), Cell Biology (B4352), Biochemistry 4361 and 4362 (C4361-2) and Quantitative Analysis (C3225)	These courses provide exposure to equipment processes and data gathering, both of which may be used in the production process.	Assessment through lab reports and maintained lab notebooks (see Sections A1 & B1)	NOT COVERED (indirect only)
C2. Perform and monitor the process to make the product or provide the service	Covered indirectly only; mostly addressed in B4325, B4352, C4361-2, C3225	It is taught to some degree in all lab courses. Data gathering, documentation, presentation of lab results and knowledge of safety procedures are assumed. All of these may be used in the production process.	Assessment is through lab reports, lab testing and maintained lab notebooks (see Section A1 & B1)	NOT COVERED (indirect only)
C3. Inspect materials at all stages of process to determine quality or condition	Covered indirectly in various courses: B4325, B4352, C3225 and more directly in C3226, and Organic chemistry (C2371-3)	Some labs are sequential and thus lab work requires assaying one step before the next step can proceed. The quality of the previous step(s) must be known before next step can be completed. Attention to detail is key.	Assessment is through lab reports, lab testing and maintained lab notebooks (see Sections A1 & B1)	LOW EMPHASIS
C4. Participate in the installation, modification and upgrade of equipment	Covered only indirectly through general lab work, as the SPU lab is an integrated Chemistry, Biology and Physics facility. Students participating in undergraduate research projects get direct exposure.	Familiarity with machinery and their use is key in all experimentation. In addition students need to have specific knowledge of pH meter calibration, spectrophotometers, microscopes, centrifuges, shakers, water baths, and incubators.	Assessment is through lab reports, and maintained lab notebooks as well as individual projects and faculty supervision (see Section A1 & B1)	NOT COVERED (indirect only)
C5. Prepare final product for shipping or distribution	Covered only indirectly through general lab work, as the SPU lab is an integrated Chemistry, Biology and Physics facility. Students participating in undergraduate research projects get direct exposure.	Instructors emphasize importance of completing a task, and accurate documentation. Students practice "follow through skills" by following lab protocols, paying attention to detail and accurate documentation all in a timely manner.	Assessment is through lab reports, and maintained lab notebooks as well as individual projects and faculty supervision (see Section A1 & B1)	NOT COVERED (indirect only)

Critical Functions and Key Activities	Where is this activity taught and practiced in the curriculum?	How is it taught and practiced?	How is it assessed?	Degree of emphasis in the curriculum?
C6. Monitor, maintain and troubleshoot equipment, tools and workstation	Covered only indirectly through general lab work, as the SPU lab is an integrated Chemistry, Biology and Physics facility. Students participating in undergraduate research projects get direct exposure.	Familiarity with machinery and their use is key in all experimentation. In addition students need to have specific knowledge of pH meter calibration, spectrophotometers, microscopes, centrifuges, shakers, water baths, and incubators.	Assessment is through lab reports, and maintained lab notebooks as well as individual projects and faculty supervision (see Section A1 & B1)	NOT COVERED (indirect only)
C7. Communicate with co-workers and/or customers to ensure production or service meets requirements	All labs emphasize workplace communication. Many labs require lab work in pairs and exchange of information prior to documentation. The exchange of information is directly covered in B3325, B4352, & B4325. In B3325 & B4352 students work in pairs and report individually. In B4325 students work individually but must communicate their results with each other. Several experiments in all these classes require sharing class data.	Instructors emphasize importance of communicating with co-workers in lab. Students practice communication skills by following lab protocols, paying attention to detail and accurate documentation.	Assessment is through lab reports, lab testing, group or team assignments and maintained lab notebooks as well as one on one observation in lab setting.	NOT COVERED (in direct only)
C8. Coordinate logistics	Covered only indirectly through general lab work, as the SPU lab is an integrated Chemistry, Biology and Physics facility. Students participating in undergraduate research projects get direct exposure. Logistic coordination and inventory control is essential to student success.	Students practice this in preparing for labs as well as by following lab protocols, where attention to detail and accurate documentation are essential. They also need to exhibit appropriate behavior and good communication in labs.	Assessment through lab reports, lab testing and maintained lab notebooks and one on one observation in lab setting.	LOW EMPHASIS
D. Maintain a safe and productive work environment				
D1. Participate in employer sponsored safety training	Every course emphasizes safety aspects. All students must attend a lab safety orientation once a year and sign a compliance sheet. Each instructor includes oral and written guidelines for safe use of equipment/ reagents in these specific labs. No first aid training is required to date, however.	Instructors and lab staff demonstrate safety procedures. Specific safety issues are provided relative to the experiments and equipment being utilized in each course and / or assignment. Faculty and staff are also required to be current in safety training.	Assessment includes quizzes, exams, and direct observation by lab staff, TAs and instructors. Failure to observe safety rules results in lab “penalties” including course “expulsion.”	HIGH EMPHASIS
D2. Participate in emergency drills and emergency response teams	All students attend an annual safety orientation, which includes discussion of emergency situations. All students are required to attend.	The safety orientation is given as and oral presentation or on videotape.	Students may not work in the lab without having attended a safety orientation and signing a compliance sheet.	LOW EMPHASIS

Critical Functions and Key Activities	Where is this activity taught and practiced in the curriculum?	How is it taught and practiced?	How is it assessed?	Degree of emphasis in the curriculum?
D3. Identify unsafe conditions and take corrective action	Instructors, lab staff, and TAs supervise the majority of Biology and Chemistry labs. They are familiar with potential problems associated with lab exercises. Students are told how to identify unsafe conditions and the possible corrective actions they may take.	Oral and written guidelines regarding safe use of equipment and reagents are provided for every lab exercise.	Instructors, lab staff, or TAs assess students mostly through direct observation.	MODERATE EMPHASIS
D4. Suggest continuous improvements	Not currently being taught and practiced in a formal manner.	N/A	N/A	NOT COVERED
D5. Coordinate with work team	In most Chemistry and Biology lab classes, students work in pairs or teams. They are expected to participate fully and to share in data collection and analysis.	Students are assigned lab partners or groups in most courses and maintain such partnerships for the duration of the lab class. Groups must coordinate their lab schedules and arrange for an equitable division of labor. Suggestions for accomplishing the work in an equitable way are given by the instructor, however, the final responsibility lies with the students.	Lab notebooks and lab reports are individually assessed where the instructor can determine individual effort. Instructors and TAs carry out direct observation of group participation.	HIGH EMPHASIS
D6. Provide orientation and training to other employees	This activity is not currently part of the curriculum. Students are not responsible for the safety training of other students.	Not taught or practiced in a formal manner.	Not assessed.	NOT COVERED
D7. Handle and dispose of hazardous materials	All chemistry and biology lab classes are given oral or written instructions in the handling and disposing of hazardous materials.	All lab exercises are on file with the lab manager in order to assess for hazardous materials and their use / disposal. The lab is in compliance with OHSHA / WSHSHA; all MSDS (Material Safety Data Sheets) are on file and available for student review.	Most assessment is through direct observation by instructors, lab staff, and TAs. Failure to observe safety rules results in lab "penalties" including course "expulsion."	HIGH EMPHASIS
D8. Maintain Security	This activity is not taught within the curriculum due to the "open" nature of our current facility; however, all students are aware of those that "belong" in lab and those that do not. All students must be wearing their CURRENT lab badges when working in the lab.	This activity is not specifically taught in the curriculum, but faculty and lab staff work to ensure a secure lab.	Not assessed	NOT COVERED

Critical Functions and Key Activities	Where is this activity taught and practiced in the curriculum?	How is it taught and practiced?	How is it assessed?	Degree of emphasis in the curriculum?
E. Perform documentation				
E1. Maintain lab notebook	Covered directly in Molecular Biology (B4325), Genetics (B3325), General Chemistry (C1211), Organic Chemistry (C2371-3), Chemical Equilibrium and Analysis (C3225), Instrumental Analysis (C3226), and Biochemistry (C4361-2)	Lab notebooks are kept in accordance with specific instructions. Some steps must be signed off by lab teaching assistants and/or instructor. In B3325, chronological informal notes as well as graded formal lab write-ups are required. In B4325, industry standard notebooks (Cold Spring Harbor Lab type) notebooks are required.	Assessment is through graded lab reports and maintained lab notebooks. Lab notebooks are periodically reviewed for progress with grades emphasizing improvement and attention to detail.	VERY HIGH EMPHASIS
E2. Create documents	Covered directly in Molecular Biology (B4325), Genetics (B3325), Cell Biology (B4352), Organic Chemistry (C2373), Chemical Equilibrium and Analysis (C3225), Instrumental Analysis (C3226), and Biochemistry (C4361-2).	Term papers and report writing are included in these courses as well as formal lab reports with documentation. Oral presentations utilizing PowerPoint (or equivalent software) are required in some courses. Data must be presented in an acceptable format and written requirements for these documents/ presentations are given to the students.	The teaching assistant(s) and/or instructor(s) grade all of these documents and presentations.	HIGH EMPHASIS
E3. Document Good Manufacturing Practices, Good Laboratory Practices and Good Clinical Practices work	Covered directly in B4325, B3325, B4352, and C4361-2 and Internship (B4940)	Guest speakers from industry emphasize these activities. The concept of GMP is presented through classroom discussion and assigned articles. GMP is "simulated" through above lab notebook and lab report writing (see Section E2)	Assessed as a component of Sections E1 and E2	MODERATE EMPHASIS
E4. Write reports	Many courses in Biology and Chemistry require written reports, including General Biology (B2101-3), Cell Biology (B4352), Molecular Biology (B4325), and Biochemistry (C4361-2).	The reports are written according to assigned format, usually following guidelines given in appropriate research journals. They may include library and on-line searching, synopses, critiques, case studies, etc.	Reports are submitted to and then graded by instructors; some may receive feedback from other students (peer review); some may be presented orally or in poster format.	HIGH EMPHASIS
E5. Maintain equipment logbooks	Carried out in some Chemistry lab courses for instruments (e.g. specific high speed centrifuge, UV-VIS spectrophotometer, FT-IR, GC's etc. Students are not expected to maintain equipment but are expected to log in and log out for their use time.	This activity is not taught in a systematic way other than via generalized lab instructions	Currently little assessment is carried out on this activity.	LOW EMPHASIS
E6. Maintain chemical / biological stock records	This activity is not currently covered. Supervisory staff maintains stocks; student's supplies are aliquoted.	This activity is not taught in a systematic way.	N/A	NOT COVERED

Critical Functions and Key Activities	Where is this activity taught and practiced in the curriculum?	How is it taught and practiced?	How is it assessed?	Degree of emphasis in the curriculum?
E7. Maintain training documentation	Covered directly in Genetics (B3325), Cell Biology (B4352), Molecular Biology (B4325), and Biochemistry (C4361-2).	All laboratory training is documented through lab notebooks and maintaining a skills portfolio.	See Section E1 for lab notebook assessment and portfolio assessment is done with individual faculty feedback.	VERY HIGH EMPHASIS

SPU PROGRAM IN BIOTECHNOLOGY GAP ANALYSIS RESULTS

The analysis of the SPU Program in Biotechnology curriculum is documented in detail in the gap analysis matrix at the end of this report. In summary, the analysis yielded the following findings:

- The SPU program has a strong emphasis within the "Research, Development, and Manufacturing" concentration of the Biotechnology and Biomedical Skills Standards. Although there are some aspects of the "Regulatory Affairs and Clinical Trials" concentration covered in some courses, the SPU program was not specifically designed to address the critical work functions and key activities described; a gap analysis was therefore not carried out on this concentration. The lack of emphasis on regulatory issues and clinical trials is due mainly to the program's origin with the College of Arts and Sciences at SPU. In the future, the program might look at expanding into this concentration by offering new courses through its School of Business and School of Health Sciences, as well as strengthening ties to selected industry partners.

- Of the 39 sections within the "Research, Development, and Manufacturing" concentration, 14 sections (36 %) currently receive high or very high emphasis by the SPU program. Of the remaining sections, 13 (33 %) receive low or moderate emphasis and 12 (31 %) receive little or no emphasis (i.e., are not covered except indirectly). Coverage is strongest within the following critical work functions: performing routine laboratory support work (category A) assisting with research and development (category B), maintaining a safe and productive work environment (category D), and performing documentation (category E). Coverage is weakest in the critical work function of manufacturing the product or providing the service (category C). This result is not surprising given the program's development within a liberal arts university where the curriculum is traditionally less vocational. On the other hand, the SPU program might increase its coverage of this manufacturing category by working more closely to develop partnerships with industry and more vocationally oriented institutions.

- Within the four critical function categories (A,B,D, and E) that serve as the focus of the SPU program are nine key activities sections which currently receive low emphasis, only indirect coverage, or no coverage in the existing curriculum. These sections are prime areas for curriculum improvement since they represent the largest gaps between program graduate skills and the entry-level skills deemed necessary by industry. The nine sections are:

A2 – Order and Stock Supplies
A7 – Send, Receive and Distribute Biological and Chemical Materials
A8 – Perform Routine Animal Care Duties
D2 – Participate in Emergency Drills and Emergency Response Teams
D4 – Suggest Continuous Improvements
D6 – Provide Orientation and Training to Other Employees
D8 – Maintain Security
E5 – Maintain Equipment Log Books
E6 – Maintain Chemical/Biological Stock Records

- The majority of the key activities are taught and practiced within the core courses of the curriculum. A significant number of the activities, however, receive emphasis either in prerequisite courses or in courses associated with degree paths in Biology, Chemistry, and Biochemistry. These courses, which include Statistics (MAT 1360), Chemical Equilibrium and Analysis (CHM 3225), and Quantitative and Instrumental Analysis (CHM 3226), should be more clearly denoted as containing content important to biotechnology program students. This might be accomplished by providing students with a table that includes the specific courses required if they are to receive a specialization in biotechnology as part of their Bachelor of Science degree in Biology, Chemistry, or Biochemistry.

- New skills and content knowledge are usually introduced through lectures and/or demonstrations and practiced to mastery through a wide range of activities and projects. A balance between group (or team) activities and individual (independent) activities is evident throughout the curriculum. The activities/projects are designed to build on prior knowledge and to foster increased self-reliance as students progress through the program. By their senior year, students are expected to prepare all their own chemical solutions, carry out and troubleshoot controlled experiments of their own design, and report their findings in oral or written form to professional standards.

- Hands-on activities and real-world scenarios are incorporated into all of the biotechnology core courses. In addition, several of the courses require that students attend on- or off-campus professional seminars where research topics relevant to biotechnology, including bioethical concerns, are presented and discussed. Students themselves must present recent research articles before their colleagues in several courses (e.g., Molecular Biology, Biochemistry, and Biochemistry/ Molecular Biology Seminar). The voluntary teaching and internship components of the curriculum also emphasize realistic situations and problems.

- The program curriculum emphasizes foundational skills that are identified as important by industry: careful planning,

attention to detail, task organization and problem solving abilities, accurate and timely documentation, exhibiting of appropriate behavior on the job, good oral and written communication.

- The technical content and skills are covered in depth throughout the curriculum. Some skills, however, such as preparation of media, solution making, and cell culture methods, are not introduced until relatively late in the program. This situation leaves little time for mastery of the skills before entering the internship component of the program. An effort should be made to introduce such skills earlier and in more depth, perhaps through articulation with community college programs where these skills are taught in dedicated courses. The technical skills specifically emphasized in the SPU curriculum include: 1) maintaining and handling biological stock cultures, 2) preparation of biological and/or chemical materials, 3) performing assays and experiments, 4) performing data analysis, 5) proper handling/disposal of hazardous material, 6) maintaining a safe work environment, 7) analyzing data, 8) maintaining lab notebooks, 9) creating documents, and 10) writing technical reports.

- Assessment of key activities is carried out throughout the curriculum using a variety of methods ranging from oral or written examinations to graded research projects evaluated one-on-one with an instructor or internship supervisor. The assessments are progressive and involve all levels of Bloom's taxonomy of learning objectives (e.g., memorization, application and problem solving, synthesis, and evaluation).