COMPUTATIONAL SCIENCES AND ROBOTICS

Student Outcomes and Assessment Plan

The program mission, objectives, and student learning outcomes are all published on the campus website and all the course assessment information is listed under, "course assessments", as a menu item on the department website at http://www.sdsmt.edu/MCS . The student learning outcomes for the CSR program have the requirements that graduates will:

1. demonstrate a strong foundation in computational sciences and robotics,
2. be able to gather relevant research from technical sources to address problems in computational sciences and robotics,
3. have specialized in-depth knowledge in at least one area of computational sciences or robotics, and
4. have experience working in teams along with demonstrated ability to communicate with others.

The CSR program is a very flexible program, but it does have a few courses that every student must complete in order to graduate. The two courses that all students in the program must complete are: Introduction to Robotics (CSC 515/515L) and a two-semester sequence of Seminar (CSC 790). The program does feature two different tracks with one track involving a two-semester sequence in thesis research (CSC 798) and the other track involving a Master's Project (CSC 788). Thus, a graduate will have completed six credits of thesis (CSC 798) or three credits of a project (CSC 788). This core set of courses is the primary cover for the student learning outcomes for the CSR program. A mapping of these courses to the program student learning outcomes can be found in the following table.

Table: Core Courses mapping to Program Student Learning Outcomes

	CSR Student Learning Outcomes			
CSR Course	#1	#2	#3	#4
CSC 515 Intro. to Robotics	X		X	X
CSC 788 Master's Project	X	X	X	
CSC 790 Seminar		X		X

CSC 798 Thesis	X	X	X	

The other elective courses in the CSR program help to bolster the coverage of the student learning outcomes and it should be noted that at least half of the courses in any program of study must include courses with the CSC prefix. This program requirement helps emphasize the coverage of student learning outcome #1, "students are able to demonstrate a strong foundation in computational sciences and robotics". The research sequence, or the master's project, are the primary venues for developing the student learning outcome #3, "students are able to have specialized in-depth knowledge in at least one area of computational sciences or robotics".

The CSC classes have been using a Course Embedded Assessment (CEA) to evaluate class performance on the course learning outcomes and this performance is reported back to the program and reviewed by the CSR Curriculum Committee. The committee regularly reviews the assessment information and makes changes based on the assessment and the feedback from constituents. The thesis credits and the master's project both involve written reports that are reviewed by the faculty involved in supervising the research. All reports and thesis documents are available on a shared department drive so faculty can readily review these materials. The CSR curriculum committee has an approved rubric for evaluating work in teaming and the results from these assignments are included in the CEA reports and reviewed by the CSR Curriculum Committee.

CRITERION 4. CONTINUOUS IMPROVEMENT

The development of the assessment plan is still ongoing and the nature of a graduate program does present special challenges to evaluate compared to an undergraduate program. In addition, CSR is a unique program that has an interdisciplinary design that is flexible, but also more specialized than what is commonly found in most post graduate programs. The tools that are part of the assessment plan along with the timeline for the assessments are given in the following table.

Table: Assessment tools and timeline for evaluation.

Assessment Tool	**Schedule for the Assessment Tool**
Student Exit Surveys	Every year
Course Embedded Assessments	Courses are regularly reviewed on a four-year rotation
Focused Curriculum Reviews	Reviews happen every semester over the courses that have collected Course Embedded Assessments in the previous semester.
Teamwork Rubric Review	Courses that cover teamwork will use a teamwork rubric to evaluate student performance and the data from that rubric will

	be part of the Course Embedded Assessment.
Thesis Reviews	Every year
Master's Project Reviews	Every year
Employer/Alumni Surveys	Every 4 years

Student Exit Surveys

One way to gather information is to survey students upon their exit from the program. The advantage of this method is that the students have recently completed the program, so all the elements of the program are fresh in their memory. This also gives us an excellent chance at gathering placement information and contact information for further use. Two major detractors are the low response rate and the fact that students are fully aware that the size of the program makes it easy for faculty to track comments back to the students. Thus, the comments are likely to be filtered and the feedback might suffer from a biased response. To improve response rates, we distribute these surveys in paper form.

CSR Student Exit Survey

We greatly appreciate you taking the time to complete an exit survey to help us continually improve our program in Computational Sciences and Robotics. Any written notes will be transcribed into typed notes and the responses will be anonymous and the summary will be aggregated together. Thank you for any constructive feedback you provide.

The objectives describe the expected accomplishments of graduates of the program approximately 3 - 5 years after graduation. A graduate of the CSR program will:

I. demonstrate a strong foundation in computational sciences and robotics,

II. be able to gather relevant research from technical sources to address problems in computational sciences and robotics,

III. have specialized in-depth knowledge in at least one area of computational sciences or robotics, and

IV. have experience working in teams along with demonstrated ability to communicate with others.

1. Should we consider adding any program objectives to the above list?

2. Should we consider deleting any program objectives from the above list?

3. What attracted you to the CSR program?

4. What is going well in the program?

5. What is not going well in the program?

5. What do plan to do upon graduation? (If you have been placed then please share the placement information along with your job title.)

7. Do you feel prepared for the next step in your professional career?

8. Were the library and laboratory facilities adequate for the research activities you conducted as part of the CSR program?

9. We would like to keep in touch with you and would appreciate a contact email address (your @mines account will eventually expire).
Can we share this email contact with the Alumni Association?

Email: _____
Share with the Alumni Association? Yes or No

Course Embedded Assessments

The department has been using Course Embedded Assessments (CEAs) for several years to measure student performance on learning outcomes. In 2015, the CSR Curriculum Committee did approve the policy that every graduate course should involve some component of scholarly work that has some kind of research component and this criterion was included for any students enrolled in a cross listed course of 400/500 level. The undergraduate course requires the use of a CEA to track progress on the course learning outcomes and this CEA includes a report that is subject to a focused curriculum review by the undergraduate program steering committee. The CSR will also require a CEA that will report on class performance for students enrolled in a graduate course and the student performance on the scholarly work that is required.

An example of a CEA is given below

CSR Course Embedded Assessment Template
Course: _____
Coordinator: _____
Semester: _____

The CSR has following program learning outcomes that graduates will:

1. demonstrate a strong foundation in computational sciences and robotics,
2. be able to gather relevant research from technical sources to address problems in computational sciences and robotics,

3. have specialized in-depth knowledge in at least one area of computational sciences or robotics, and
4. have experience working in teams along with demonstrated ability to communicate with others.

Department policy requires all MATH and CSC graduate courses to include a scholarly component and this requirement is also included in any course that is cross listed at the 400/500 level.

I. Description of the Scholarly Component of the Class

What was the assessment that was used? Have you used an assessment like this in a class before?

II. Outcomes - Identify the program learning outcomes that are covered by the assessment used?

(Please place X on learning outcomes addressed)

1. ____ demonstrate a strong foundation in computational sciences and robotics,
2. ____ be able to gather relevant research from technical sources to address problems in computational sciences and robotics,
3. ____ have specialized in-depth knowledge in at least one area of computational sciences or robotics, and
4. ____ have experience working in teams along with demonstrated ability to communicate with others.

III. Evaluation of Student Performance

Describe how the graduate students performed on the assignment. If there is a significant number of graduate students that are not CSR students then please describe the performance of the CSR students compared to the overall graduate student population in the class. The benchmark is that 80% of graduate students would perform on the assessment at a B or higher level, but benchmarks can vary depending on the difficulty of the assessment. Please report the performance of the CSR students relatively to the appropriate benchmark.

IV. Grade Distribution: Course grade distribution of the graduate students (if there are a significant number of non-CSR graduate students then please report the grade distribution of the CSR students compared to the overall grade distribution for graduate students.

A:
B:
C:

D:
F:

V. Future Considerations:

What would you change to address what went wrong (if anything – could have been a bad class)? Is there anything that you did that was new or innovative that really worked and you think that practice should be retained in future offerings?

Focused Curriculum Reviews

The focused curriculum review is a gathering of the CSR faculty to review the CEAs gathered in the previous semester. These reviews analyze the results and recommendations given in each of the CEA reports and these findings are then discussed. The focused curriculum review is an opportunity to close the loop on assessment activities and provide an opportunity to discuss this information in the context of programmatic assessment.

Teamwork Rubric Review

The Computer Science Curriculum committee produced a teamwork rubric for for undergraduate classes and the same rubric was adapted for use in graduate courses. In some cases, faculty may have specialized rubrics that accompany specific group assignments and data gathered from these sources can still inform the CSR committee on student performance related to teamwork. The evaluations from any team assignments are incorporated in the class course embedded assessment and reviewed in the next focused curriculum review.

Category	5	4	3	1	Total
Work	**Individual work strengthens the overall group project.**	**Individual work is sufficient for the overall group project.**	**Individual work is a weakness for the overall group project.**	**Individual work is lacking and negatively impacts the overall group project.**	
Communication	**Individual consistently fostered good communications with other team members and/or client.**	**Individual usually fostered good communications with other team members and/or the client.**	**Individual struggled in communicating with other team members and/or the client.**	**Individual lacked communication with other team members and/or the client.**	
Contributions	**Individual had clear contributions to the project and consistently produced quality work according to group defined deadlines.**	**Individual had clear contributions to the project and usually produced quality work according to group defined deadlines.**	**Individual contributions are not clear and there is evidence of low group satisfaction with work quality and/or timeliness.**	**Individual contributions are lacking and negatively impacted the project.**	
Peer Evaluation	**Group members highly rated the individual.**	**Group members were satisfied with performance**	**Group members were somewhat satisfied with**	**Group members were not satisfied with performance**	

		of the individual.	**performance of the individual.**	**of the individual.**	
Problem Solving	**Individual consistently worked to further the progress of the team and listened to team members to help identify the best possible solutions.**	**Individual clearly documented an active participation in solving project problems.**	**Individual has a record of some active participation in solving project problems.**	**Individual lacks evidence of active participation in solving project problems.**	

The committee also developed a handout as a resource that would help students that face challenges in a team assignment. The handout provides a few suggestions on common pitfalls that have been observed over the years with ideas on how to address them.

Tips When a Team is Having Problems

It is very common to face challenges when working in a team. The strategies are different depending on your role on the team and list of suggestions is a general guidance for a team member and is not necessarily applicable to the team leader. If you are team leader on a class project then you might want to speak with your instructor regarding the team problems you encounter.

1. **Communication** – The root to most team problems is communication. If you encounter problems with progress on the project it is important to communicate this to your team leader. If the particular problem is connected to other components of the project that involves other team members then it is important to communicate with the team members. It is also important to communicate these types of problems early so people are aware. It is also useful to identify the best way to communicate with someone. Some people prefer email and other prefer phone or text, but others will only respond to instant messaging. It is easy to ask a person what is the best way to communicate with them and you can also inform your team members what method works best for you.
2. **Keep it Professional** – You might be friends with a few members of the team, but it is likely you are not friends with everyone. The work environment does not have to be a bleak existence, but it is also not a party. You should be careful in your use of humor since everyone has their own personal taste in humor. Email is a particularly poor forum for humor since it is difficult for a reader to interpret sarcasm in an email. Teams are not a place for romance and you should not use team activities as an opportunity to pursue romantic interests. It is best to pursue romantic interest after the project is over. If you are romantically involved with a team member it is best to leave romantic gestures outside team meetings and team communications since the other team members will not enjoy being assigned to the "Love Boat" team. Quality couple time should occur outside team activities.
3. **Be on time** – Being late to meetings, or late with deliverables, is an automatic drag on resources. Many people view being late to a meeting as sign of disrespect and will note such slights in their future dealings with you. If you run into complications that make you late with a deliverable, or a meeting, then be sure to communicate as soon as possible with your team.
4. **Be proactive** – Bad team members do not follow through, but weak team members only do as they are told. In a work environment, you will need to prove you are valuable to the company or you will likely find yourself out of a job. We do allow teams in our department to fire a team member, which means you could be kicked out of your project at the end of the semester when the project is due. The best advice is to make yourself valuable to the team and look to help in any area of the project that might need help. Managers and

team leaders can quickly identify the people they can count on and those are the individuals that are valued.
5. **Manage Conflict** - Please notice that the title to this section did not say to avoid confrontation. It may be necessary to confront serious issues within the team, but it is important to manage these encounters. Keeping the conversation professional is crucial and you should avoid any personal attacks. The best conversations occur face to face and in private so this is the best approach if you have a simple issue with a fellow team member. If you have a serious issue that would not be appropriate to resolve individually then you should seek the assistance of your team leader or the instructor. For more serious issues you can seek the advice of the counselors in the Dean of Students Office or the Dean of Students.
6. **Documentation**- Documentation is a tedious practice, but it can help you if things go seriously wrong. Keeping notes of team meetings, keeping notes of your work, archiving emails, and writing regular reports are all ways to provide evidence if there is ever a review or a question regarding your work. For example, consider the case that you are on a team that fails to meet a major deadline. Accurate records of your work will support your participation in the project and protect you from assignments of blame. If you were aware of a fundamental problem that was stalling the project then your emails of communication regarding the problem and possible solutions you posed will help support your case. The project management systems that archive work can help team members track progress and coordinate effort, but they are also fantastic ways to document your involvement.

Thesis Reviews and Master's Project Reviews

Every thesis student has a graduate committee to guide the research and evaluate the work submitted by the student. The CSR faculty members of the committee are asked to provide input to the faculty advisor on the project, and these committee members develop a consensus regarding the evaluation of the thesis research relative to the rubric given below. Every non-thesis student completes a project and the faculty advisor and an additional CSR faculty member evaluate the project relative to the given rubric. In general, the entire CSR faculty is given access to all thesis and project reports on a shared drive along with the completed rubrics. The results of these evaluations are regularly reviewed by the CSR committee every year and the results are used to suggest any changes that might be needed to the program.

Master of Computational Sciences and Robotics Research Evaluation

_____ M.S. Project _____M.S. Thesis

Instructions: Committee members/appropriate faculty should discuss each item and arrive at a majority opinion. Circle or place an X in the appropriate box and comment as desired. The form is used only for program assessment purposes rather than individual student performance.

Students demonstrate a strong foundation in computational sciences and robotics				
Criteria	**(1) Needs work**	**(2) Proficient**	**(3) Mastery**	**Comments**
Depth	The project does not demonstrate adequate knowledge in computational sciences or robotics.	The project does demonstrate adequate knowledge in computational sciences or robotics	The project demonstrates an exceptional level of knowledge in computational sciences or robotics	
Breadth	The research draws very little connection to related concepts.	The research has adequate connection to related concepts and theories in the discipline.	The research demonstrates a broad understanding of the connections to related concepts and theories in the discipline.	
Students will be able to gather relevant research from technical sources to address problems in computational sciences and robotics				
Gather Relevant Research	The project lacks support from credible sources.	The project demonstrates sufficient support from technical resources.	The project demonstrates extensive support from relevant sources in the discipline.	
Students have specialized in-depth knowledge in at least one area of computational sciences or robotics				
Knowledge	Project demonstrates rudimentary knowledge of subject.	Project covers subject matter with adequate technical knowledge basis.	Project demonstrates mastery of the technical knowledge associated with the subject matter.	

Evaluation	The project fails to consider flaws or potential errors.	The project does adequately consider flaws and potential errors in the work.	The project demonstrates a deep understanding of the limitation of the presented work and accurately places the conclusion relative to the current literature.	

Employer/Alumni Surveys

The CSR program plans to regularly engage alumni in order to study the relevance of our CSR degree in a rapidly changing profession. The information that is gathered can be limited since the program is new and the size of the program is relatively small. In order to take advantage of our contacts with employers we also utilize an employer survey so we can benefit from their feedback and give us flexibility to gather input from people that are not alumni.

Alumni Survey

Thank you for taking the time to complete this survey. This survey is to gather feedback on our program learning outcomes. The program learning outcomes represent the expected characteristics of a graduate from the Masters of Science degree in Computational Sciences and Robotics (CSR) from the South Dakota School of Mines and Technology. The program learning outcomes state that the graduates of the CSR program will:

I. demonstrate a strong foundation in computational sciences and robotics,
II. be able to gather relevant research from technical sources to address problems in computational sciences and robotics,
III. have specialized in-depth knowledge in at least one area of computational sciences or robotics, and
IV. have experience working in teams along with demonstrated ability to communicate with others.

1. Are the program learning outcomes appropriate for a graduate of the CSR program?
   Strongly agree Agree Neutral Disagree Strongly Disagree Not sure
2. I have been able to achieve program learning outcome #1: “demonstrate a strong foundation in computational sciences and robotics”
   Strongly agree Agree Neutral Disagree Strongly Disagree Not sure
3. I have been able to achieve program learning outcome #2: “be able to gather relevant research from technical sources to address problems in computational sciences and robotics”
   Strongly agree Agree Neutral Disagree Strongly Disagree Not sure

4. I have been able to achieve program learning outcome #3:" have specialized in-depth knowledge in at least one area of computational sciences or robotics"
   Strongly agree Agree Neutral Disagree Strongly Disagree Not sure

5. I have been able to achieve program learning outcome #4: "have experience working in teams along with demonstrated ability to communicate with others"
   Strongly agree Agree Neutral Disagree Strongly Disagree Not sure
6. Are there any program objectives that should be removed from this list? If so, please indicate which ones.

7. Are there any program objectives missing from this list? If so, please describe what they are.

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8. I have found my degree from SDSM&T has prepared me well for my chosen career.
   Strongly agree Agree Neutral Disagree Strongly Disagree Not Applicable

9. What are the strongest features of our CSR program?

10. What are areas of potential concern for our CSR program?

Employer Survey

Thank you for taking the time to complete this survey. This survey is to gather feedback on our program learning outcomes. The program learning outcomes represent the expected characteristics of a graduate from the Masters of Science degree in Computational Sciences and Robotics (CSR) from the South Dakota School of Mines and Technology. The program learning outcomes state that the graduates of the CSR program will:

I. demonstrate a strong foundation in computational sciences and robotics,
II. be able to gather relevant research from technical sources to address problems in computational sciences and robotics,
III. have specialized in-depth knowledge in at least one area of computational sciences or robotics, and
IV. have experience working in teams along with demonstrated ability to communicate with others.

1. The learning outcome #1: "demonstrate a strong foundation in computational sciences and robotics" is appropriate for a graduate seeking employment in my organization.
   Strongly agree Agree Neutral Disagree Strongly Disagree Not sure

2. The learning outcome #2: "be able to gather relevant research from technical sources to address problems in computational sciences and robotics" is appropriate for a graduate seeking

employment in my organization.
Strongly agree Agree Neutral Disagree Strongly Disagree Not sure

3. The learning outcome #3:" have specialized in-depth knowledge in at least one area of computational sciences or robotics" is appropriate for a graduate seeking employment in my organization.
Strongly agree Agree Neutral Disagree Strongly Disagree Not sure

4. The learning outcome #4: "have experience working in teams along with demonstrated ability to communicate with others" is appropriate for a graduate seeking employment in my organization.
Strongly agree Agree Neutral Disagree Strongly Disagree Not sure

5. Are there any program objectives that should be removed from this list? If so, please indicate which ones.

6. Are there any program objectives missing from this list? If so, please describe what they are.

7. I have found graduates from the CSR program are well prepared for a career in my organization.
Strongly agree Agree Neutral Disagree Strongly Disagree Not Applicable

8. What are the strongest features of our CSR program?

9. What are areas of potential concern for our CSR program?

Review of Curriculum Changes

The M.S. in Computational Sciences and Robotics started in the spring semester of 2012 and one of the new additions to the new program was the incorporation of a two semester sequence of seminar. Originally, the seminar was created as ½ credit per offering and this structure was changed in the fall semester of 2014 due to a mandate from the South Dakota Board of Regents that the credits for all courses be valued in integer quantities. The introduction of the seminar was based on industry feedback that communication and teaming skills should be emphasized more in the program. The new seminar also provided an opportunity to introduce the fundamental tools in research along with an overview of the research activities taking place in the department.

The academic year of 2012-2013 resulted in the deletion of the CSC 505 course, which was a Data Structures course designed for the RIAS program. The focus of the new CSR program placed computing more central to the program and an expectation that students new to the program would have a strong Data Structures background. Students who lacked sufficient background in Data Structures would take the undergraduate Data Structures class and this

coursework could not be counted towards a program of study. The program has been successful in recruiting students from other majors with recent graduates from: Mechanical Engineering, Computer Engineering, Chemical Engineering, and Chemistry. Thus, the CSR program remains interdisciplinary in nature and open to a variety of majors with the prudent move to secure data structures as a proper prerequisite.

The academic year of 2013-2014 includes the establishment of two new courses: CSC 541 (Networking and Data Communications) and CSC 576/576L (Mobile Computing Development). The new networking class replaced an old course in data communications while the mobile computing course is the result of addressing a rapidly growing area of the industry. The academic year of 2014-2015 included the removal of the Autonomous Systems course (CSC 516) that was part of the required core to the old RIAS program. The feedback from students and industry indicated that a broader coverage that included Artificial Intelligence and Machine Learning was more flexible and provided a broader variety of educational and research opportunities. In the spring semester of 2016 the CSC 516 course number would return as our new course in Advanced Algorithms for Robotics. The development of CSC 516 came from student feedback that suggested increasing the course offerings in robotics and this suggestion coupled well with the fact that we currently have both Dr. Pyeatt and Dr. McGough on the faculty. Multiple faculty active in robotics research allows us the opportunity to broaden our offerings and regularly offer the introduction to robotics course. The program extended the focus on robotics further by increasing the credits assigned to CSC 515/515L to 4 credits.

Data Structures has always been a pivotal class and the elevated status of Data Structures in the CSR program did result in a curriculum change that pushed for higher proficiency in Data Structures with the requirement that a student have at least a C or better in Data Structures as a prerequisite to several courses in the curriculum. The courses in CSR that adopted this higher standard in Data Structures are: CSC 510 (Parallel Computing), CSC 526 (Cybersecurity), CSC 533 (Computer Graphics), CSC 542 (Digital Image Processing), CSC 547 (Artificial Intelligence), CSC 548 (Machine Learning), and CSC 748 (Machine Learning). A few other changes in curriculum include the replacement of CSC 549 (Pattern Recognition) with a different course title and description of CSC 549 (Advanced Topics in Artificial Intelligence). Changes in staffing made it more difficult to retain pattern recognition as a course and the revision allowed for a bit more flexibility. The program also saw the introduction of a another new course in CSC 554 (Data Mining Theory), which provided background in a very rapidly growing area in the discipline.

Lastly, the common course number structure for the state system made it impossible to alter common courses and CSC 300 (Data Structures) is a common course. The CSC Curriculum Committee proposed a new course that was a better match for the needs of our constituents with the new course being CSC 315 (Data Structures and Algorithms). The course was approved by the state system in the spring of 2015 and so our curriculum committee started to incorporate this new course into the prerequisite structure of our courses, which was completed for all the courses unique to SDSM&T campus: CSC 516 (Advanced Algorithms for Robotics), CSC 526 (Cybersecurity), CSC 541 (Networking and Data Communication), CSC 542 (Digital Image

Processing), and CSC 549 (Advanced Topics in Artificial Intelligence). The curriculum requests to bring about the same changes in the common courses were not approved by administrators in the Board of Regents office. The same situation exists for a our new and unique course, CSC 215 (Programming Techniques), and this course was approved as a prerequisite for the unique courses of: CSC 512 (Cryptography) and CSC 554 (Data Mining Theory).

Future Plans

One of the more prominent changes in recent years came with the introduction of the accelerated program in 2013. This curriculum feature allows an undergraduate student to apply to the masters program early and start taking graduate courses while a student is still an undergraduate. Furthermore, an accelerated student has the ability to double count up to ten credits of graduate courses and this means that the ten credits count in the undergraduate program and they also count in the graduate program. This specialized structure enables a student to finish their M.S. degree within a year of graduating from the undergraduate degree. The economic benefit and the accelerated nature of finishing in just one more year has proven attractive to our students and we have been able to retain a much larger number of current students into the CSR program. This recruitment strategy does often encounter the challenge of retaining the accelerated students given the minimal support available in graduate teaching assistantships. It is common that accelerated students finish the undergraduate degree and are drawn away due to the high salary offers available in industry.

Funding for graduate students continues to be a challenge for our program. The department resources to fund graduate students is low and campus policies results in teaching assistants being required to pay a reduced rate of tuition and fees instead of having these expenses waived. The department continues to seek external funding opportunities so that additional funds can be retained to pay research assistantships.

More graduate students have been able to self-support their education, which has traditionally been a rare characteristic in previous years. Some of the self-supported students bring industrial experience and this characteristic has helped enhance a few of the chosen research projects that have been produced in recent years. Lastly, the number of international applications and applications from students outside the university has declined in recent years. It is unlikely the sparse level of funding from the department for teaching assistantships will be able to significantly alter the trends in applications.