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Assessment of Communication Skills during an NSF REU Program Related to Sustainable Management of Wastes and Byproducts

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Abstract

A National Science Foundation (NSF) Research Experiences for Undergraduates (REU) site was established through the Global Waste Research Institute (GWRI) at California Polytechnic State University, San Luis Obispo (Cal Poly) to engage students in research related to sustainable management of wastes and byproducts. Project themes included waste containment, waste-to-energy conversion, remediation of contaminated sites, sustainable underground construction, and beneficial reuse of byproducts in geotechnical engineering applications. The principal investigators, faculty researchers, and graduate student mentors have assessed various program and participant activities with an emphasis on participant communication skills (oral, written, and graphical modes) throughout various phases of the summer research experience. Tools used for assessment included: learning style and communication style surveys; incremental and final perception surveys; review of weekly journal entries; peer reviews; review of communication-focused assignments (i.e., mid-program and final oral presentations, poster presentations, and voicemail reports); and documentation of experimental procedures and results in a summary report. Several activities in the program involved the use of different learning styles such as graphics-only and rapid, oral-only communication exercises. The learning-style-specific exercises were assessed for student performance and pedagogical effectiveness. Overall, the emphasis on communication skills has led to participant improvements in this area. The paper summarizes some of the challenges encountered during implementation of the communication skill activities and exercises.

Introduction

The Global Waste Research Institute (GWRI) at California Polytechnic State University, San Luis Obispo (Cal Poly) established and implemented a National Science Foundation (NSF) Research Experiences for Undergraduates (REU) site to engage undergraduates in research related to sustainable management of wastes and byproducts. Research project themes include waste containment, waste-to-energy conversion, remediation of contaminated sites, sustainable underground construction, and beneficial reuse of byproducts in geotechnical engineering applications. The REU program at Cal Poly is designed for the student participants to achieve the following learning outcomes: (1) design, conduct, and document a research experiment; (2) function effectively in a multi-disciplinary research team; and (3) document both the technical and experiential aspects of the research experience.

The undergraduate participants need to demonstrate effective communication skills to succeed in attaining all three program learning outcomes. Even if a student can succeed at conducting experiments and may succeed in discovering breakthrough findings in her/his field of research, the long-term value of these findings is likely undermined if the researcher is unable to clearly convey experimental methodology, results, and conclusions. Therefore, the REU program at Cal Poly strongly emphasizes student communication skills (oral, written, and graphical modes) and

improvement of these skills during the 10-week experience. The paper summarizes specific REU activities implemented to improve student communication skills. The tools used for assessment are discussed. In addition, program experiences, challenges encountered, and strategies employed while incorporating various assessment methodologies and tools are described.

The REU program Description and Attributes

During the summer of 2014, ten undergraduate students participated in a 10-week research experience at Cal Poly. Over the 10-week period, the students conducted advanced experimental and analytical research while also participating in structured professional development activities. These activities included (1) interactive seminars and workshops on research best practices, laboratory safety, communication styles, learning styles, and effective presentation of research findings; (2) periodic sharing of results; (3) group learning activities; (4) graduate school discussions and presentations; (5) technical field trips and interactions with practitioners; and (6) social activities. The professional development activities and experiences are of equal importance to engaging students in research. These activities improve communication, teamwork, and professional skills and result in a comprehensive and integrated research experience that prepares the participants for successful research-related careers.

The research projects associated with the REU program included novel research with engineering significance and were developed by experts from multiple disciplines at Cal Poly. These projects focused on the essential elements of scientific research: designing experiments (apparatus, procedure, and data collection); collaborating with other researchers; conducting laboratory and field experiments; analyzing data and developing correlations; conducting parametric evaluations; developing computer code for conducting numerical analyses; and comparing experimental results in the context of a theoretical framework. Engaging the undergraduates in these activities ensured their exposure to the various components of a typical research experience. Each REU participant was responsible for several project deliverables such as developing graphical presentation of experimental results for dissemination; presenting research results in oral, written, and/or alternative presentation formats; and writing an executive summary. Deadlines for the deliverables extended throughout the duration of the REU program.

Communications Emphasis

The REU program was designed to help the participants develop effective communication skills (oral, written, and graphical modes). Outcomes were addressed through various activities implemented over the duration of the 10-week program. The first of these activities took place during orientation where the undergraduate students as well as the research mentors participated in communication style exercises. Communication styles are based on the degree to which the individual is assertive and outgoing[1,2]. The participants also completed a Myers-Briggs personality type indicator survey and a learning style survey[3]. After completing these surveys, the research team members shared and discussed the survey results in an effort to enhance communication, teaching, and learning among the team members. Personality assessment tools such as those implemented herein assist team members to understand each other and improve

interpersonal communication[4]. Later during the REU program, the participants were asked to apply their understanding of communication style and personality type by assessing and justifying style and type for other members of the REU team. An example assignment is included in the Appendix.

In addition to the communication style and personality type exercises, activities were implemented to assist students in developing effective communication skills, including weekly meetings with mentors and research faculty, weekly writing assignments, mentor-led meetings designed to emphasize group discussions and activities, poster presentations, and oral presentations. The weekly meetings with mentors and/or faculty generally focused on research and included discussions of the previous week's work as well as future plans. The weekly writing assignments consisted of progress reports in which the students reflected on accomplishments and challenges during the preceding week. In some occasions, the writing assignments were more than just a progress report and included extra requirements: (1) each student was asked, as part of one report, to provide a concise and descriptive title for their research project, assuming this title would be used to describe a technical paper, research poster, and/or research report; (2) each participant provided a list of specific opportunities/avenues for publishing their research findings after consulting with their research faculty advisors and graduate student mentors; and (3) the participants prepared short abstracts for important papers they reviewed as part of a literature review requirement.

The mentor-led meetings included workshops and brown-bag seminars where the participants exchanged ideas, practiced communication skills, and discussed specific topics such as data analysis, best laboratory practices, contemporary issues, effective presentations, report preparation, and graduate school opportunities. During these meetings each of the participants was encouraged to contribute to the discussions in a clear and respectful manner. Students practiced active listening skills and learned techniques for providing and accepting feedback. The participants, faculty, and graduate students also met informally by arranging occasional group social activities. These activities helped to improve communication, teamwork, and collaboration. The activities provided opportunities for interactions between the faculty and students in a more relaxed and comfortable setting.

The REU team at Cal Poly placed significant effort on the development and assessment of oral and poster presentations. Each undergraduate participant formally presented their research findings twice during the 10-week program: once during week six (oral presentation only) and once during week ten (oral and poster presentation). Prior to the oral and poster presentations, the research mentors provided the participants with guidelines, tips, examples, and online references related to research poster preparation and effective oral presentation. In addition, participants were required to meet with their graduate student mentors prior to the presentation dates to receive feedback and guidance. An example "tip sheet" for the poster presentations is included in the Appendix.

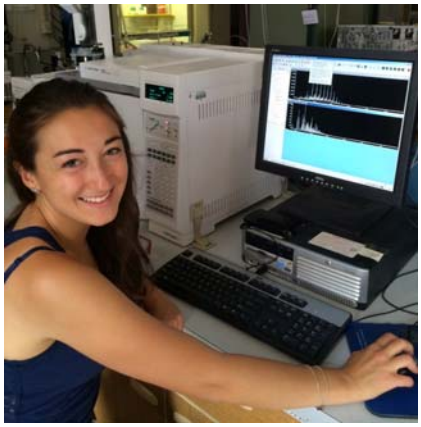
Alternative Learning Style Activities

The REU team at Cal Poly adopted strategies and activities for improving communication skills by incorporating unconventional learning styles. Graphics-only exercises and assignments were

implemented. Participants were required to submit one progress report in the form of a photo essay (visual learning style) with a highly constrained word count. Examples of the student work from this assignment are presented in Figure 1 (presented with the photo captions provided by the students). Instructions were provided to the participants for each of the alternative learning style exercises.

a) Identifying algae under the microscope using picture aids

b) Collecting research supplies from the WWTP



c) Using the gas chromatograph/ mass spectrometer

d) Weekend visit to Baker Beach

Figure 1. Example components of photo essays

Verbal learning style was implemented by assigning a telephone-based exercise. The participants submitted one of their weekly progress reports as a telephone voicemail message. The length of the phone message was constrained and the professional tone of the message was assessed. Assessment also included: command of the subject matter; the extent of detailing the purpose of the call; focus on the topic; enthusiasm, energy, and confidence; clarity and precision of

explanations; voice (volume, speed, and variation); time management; and understanding of the voice mail system.

Assessment Tools

Exercises were conducted throughout the various phases of the summer research experience to assess participant communication skills. Tools used for assessment included: learning style and communication style surveys, review of weekly journal entries, peer reviews, review of communication-focused assignments (i.e., mid-program and final oral presentations, poster presentations, photo essays, and voicemail reports), student self-review of oral presentations through critique of video-recorded presentations, and documentation of experimental procedures and results in a summary report. The principal investigators, faculty researchers, and graduate student mentors used scoring guides and rubrics when assessing student work in order to ensure consistency and reliability in the program assessment and evaluation[4]. Examples of scoring rubrics for oral presentation, telephone voicemail exercise, photo essay, and poster presentation are provided in Figures 2 to 5.

The oral presentations were video-recorded and made available to the participants for review. Each participant self-assessed their presentation strengths and areas for improvement. Research faculty, graduate student mentors, and peers assessed the content and delivery of the oral presentations providing strengths and areas for improvement for each presenter. Specific assessment criteria were used for each evaluation and included: command of the subject matter; orientation to the subject matter and goals; introduction and concluding statements; transitions; enthusiasm, energy, and confidence; clarity of the presentation slides; clarity and precision of explanations; voice (volume, speed, and variation); non-verbal communication; use of visual aids (e.g., figures, tables, etc.); posing and answering questions; understanding and contact with audience; time management; and presenter appearance. The presentation assessment sheets were based on the guidelines developed through the American Society of Civil Engineers (ASCE) ExCEEd Teaching Workshop. The assessment categories for posters included: completeness of storyline presented; organization of the information; quality of the technical writing; quality of the figures, tables, and graphics; and overall clarity of presentation.

The participants received copies of their evaluations to assist with identifying areas for improvement. In the case of the oral presentations, assessment was formative. The participants were expected to directly implement areas for improvement during their final oral presentation, based on feedback provided during the mid-program oral presentation. Demographic information surveys, pre-visit participant surveys, and post-appointment (exit) surveys for assessing the overall REU experience also were used. In the meantime, the faculty members and graduate student mentors also assessed the program and discussed areas for improvement to be addressed during subsequent program offerings.

Project Results

The research team was generally satisfied with the performance of the students in terms of the demonstration of various communication modes and improvement in communication skills

throughout the summer experience. The oral presentations provided an opportunity for directly measuring potential improvement in public speaking skills and development of visual aids for an oral presentation. Three important areas for improvement are specifically noted at the end of the oral presentation assessment form. Emphasis was placed on having each participant address these areas of improvement during their final oral presentation. During the final oral presentations, each participant addressed these areas of improvement and improved in each area. A summary of the assessment of the oral presentations (mid-program presentation and final presentation) is presented in Table 1. To the participants' credit, they took this exercise seriously and made a conscious decision to change their presentation style and improve their oral presentation skills. The strong response of students to the suggested areas for improvement was attributed to the formal evaluation rubrics and the variety of feedback mechanisms. Progressive feedback to the students numerous times over the 10-week REU program was deemed critical in promoting and attaining improvement in the communication skills of the participants.

PRESENTATION ASSESSMENT WORKSHEET

Presenter: REU Participant #7 Assessed By: [redacted]

Presentation Topic: Algae Biomass Date: 7/24/2014

STRENGTHS:	
1	Good voice pitch and level changes, but needs to project voice better (see below)
2	Slides are organized and not too cluttered; easy to read for most part
3	Good work summarizing the previous research findings and sources of information
4	Good use of photos and graphics to engage the audience
5	Exhibiting some energy and enthusiasm, smiling occasionally
6	Presentation is organized
7	Appears comfortable in front of the audience, though be careful getting too relaxed
8	Some good use of hand gestures to emphasize important points; good facial gestures
9	Articulating words and speech is clear; not many verbal idiosyncrasies (uhms, ahhs, etc.)
10	Graphs pretty easy to read with large fonts, tick marks, gridlines, etc.
11	Not using notes; evidence that you practiced the presentation beforehand
12	Pace of speech is good
13	Good explanations of technical details related to the project; knowledgeable in subject
14	Appears confident; did a good job answering questions
AREAS FOR IMPROVEMENT:	
15	Voice level is much too low; persons in back could not hear all of your presentation
16	Eye contact can be improved, speaking to screen sometimes; face audience throughout
17	Presentation did not include much introduction, discussion of "big picture" items
18	When presenting graph, explain axes and data first, followed by conclusions/observations
19	Some text is difficult to read on the slides due to font size and/or color contrast
20	Some fidgeting maybe due to nervousness (rocking, hand in pocket, weak gestures, etc.)
21	Some terminology and explanations possibly above audience; remember audience
~~22~~	qualifications, experience, and knowledge when preparing presentation
23	Some explanations and reasons behind your experiments could be clearer
24	Think about staging your photos more carefully - pictures worth 1000 words
25	What are the overall project goals and where does this research fit?
26	Careful with your time management; presentation was practiced but went over 16 min
27	Know your equipment and practice beforehand (slide clicker problems interrupted
~~28~~	the presentation on a couple of occasions

Figure 2a. Assessment rubric for the first oral presentation by an REU Participant – reviewer comments

ADDITIONAL COMMENTS:	
29	Don't be afraid to include an outline slide at the beginning to map where you are headed
~~30~~	with your presentation; could also use a conclusions/summary slide to wrap up your talk
~~31~~	and reinforce important points
32	
33	
34	
35	
36	

Assessment Categories	Needs Work	Good Job	Excellent Job	Remarks
TECHNICAL EXPERTISE				
Command of Subject Matter			x	3, 11
LESSON ORGANIZATION				
Orientation to Subject and Goals	x			17, 25
Intro and Concluding Statements	x			29
Transitions		x		6
CONDUCT OF THE PRESENTATION				
Enthusiasm, Energy, Confidence		x		5, 7, 14
Clarity of PowerPoint Slides		x		2, 19, 21
Clarity & Precision of Explanations	x			13, 18, 21, 23
Voice (volume, speed, variation)	x			1, 9, 12, 15
Non-Verbal Communication		x		8, 20
Visual Aids (figures, tables, etc.)		x		4, 10, 24, 27
Questioning & Answering Questions			x	
Understanding & Contact w/ Audience		x		16
Time Management	x			26
PRESENTATION ENVIRONMENT				
Room and Presenter Appearance		x		
OVERALL ASSESSMENT				
Can the audience members summarize the main points of your presentation, the objectives of your work, and the principal findings?			No	Not Sure / Yes

Specific areas on which to focus during your next presentation:

1.) Projection of voice throughout the room; you need to be louder

2.) Orientation to your research and discussion of bigger picture.

3.) Non-verbal communication and occasional fidgeting

Figure 2b. Assessment rubric for the first oral presentation by an REU Participant – reviewer scoring

VOICE MAIL ASSESSMENT WORKSHEET

Name: REU Participant #9

Assessment Categories	Needs Work	Good Job	Excellent Job	Remarks
TECHNICAL EXPERTISE				
Command of Subject Matter			x	
MESSAGE ORGANIZATION				
Detailed the Purpose of Call		x		
Provided Contact Information	x			Only first name provided
Focused on Topic			x	Provided requested info; no fluff
CONDUCT OF THE SPEAKER				
Enthusiasm, Energy, Confidence			x	
Clarity & Precision of Explanations		x		Speech a little choppy at times
Voice (volume, speed, variation)	x			Many idiosyncrasies - be careful
Undrestanding the Audience			x	Limited use of jargon
Time Management			x	Duration: 2:20; timing is great
LOGISTICS				
Understood Voice Mail System			x	
Completed Assignment by Deadline			x	
OVERALL ASSESSMENT				
Can the person who received your voice mail message summarize the main points of your call?			No / Not Sure / Yes	

Specific areas on which to focus when leaving your next voice mail message:

Be sure to leave your full name and let me know how I can contact you if I have questions or need to follow up. Your speech was a little choppy at times (as if you lost your place), which was somewhat distracting. Your voice volume and speed were good; however, your speech includes a lot of verbal idiosyncrasies. You said he words uhm, uh, like, yep, and yea many times throughout the call, which made it more difficult to understand and focus on your comments.

Figure 3. Example assessment rubric for the voicemail assignment

PHOTO REPORT ASSESSMENT WORKSHEET

Name: REU Participant #3

Assessment Categories	Needs Work	Good Job	Excellent Job	Remarks
Tells a Complete Story of Week			x	Covering a lot of different aspects of your work week!
Photo Composition		x		Good job; as discussed, think about backgrounds, labeling, etc.
Photo Clarity and Resolution			x	Good; nice shots of computer screens; some focus/lighting issues
Interesting Variety of Photos			x	Nice variety; did you consider some 'fun' photos to describe non-work activities?
Photo Captions			x	Descriptive; remember to define all acronyms.
Easy to Interpret			x	Very well organized and annotated; chronological
Manageable File Size		x		5.7 MB WORD file - fairly easy to download with my internet connection
Completed by Deadline			x	On time; submitted day before due date

OVERALL ASSESSMENT			
Can the person who reviews your photo report understand your principal research tasks, activities, and findings from the previous week?	No	Not Sure	Yes

Additional Comments:

Really nice job! Exactly what we were looking for. Thanks for taking the time to put together a descriptive report.

Figure 4. Example assessment rubric for the photo essay

POSTER PRESENTATION ASSESSMENT WORKSHEET

Name: REU Participant #1

Assessment Categories	Needs Work	Good Job	Excellent Job	Remarks
Tells a Complete Story			x	
Appropriate Use of Sections		x		
Organization of Information		x		Presenting a LOT of information; maximizing potential.
Easy to Read and Interpret		x		
Technical Writing			x	Good job, overall
Figures, Tables, and Graphics		x		Some resolution issues with graphics. Font size and graphics a little small.
Aesthetics and Overall Presentation		x		Some crowding with little clear space
Followed Instructions		x		

OVERALL ASSESSMENT			
Can the person who reviews your poster understand your principal research tasks, activities, and findings?	No	Not Sure	Yes

Additional Comments:

Overall evaluation: This is an above average presentation.

Figure 5. Example assessment rubric for the poster presentation

Table 1. Comparison of Initial and Final Presentation Scores for REU Participants

Assessment Categories	Tally of Presentation Scores Mid-Program (Final)			Tally of Final Presentation Comparison & Improvement			Number of Participants with Same or Improved Score
	Needs Work	Good Job	Excellent Job	Lower Score	Stayed Same	Higher Score	
Technical Expertise							
Command of Subject Matter	0(0)	3(5)	7(5)	3	6	1	7
Presentation Organization							
Orientation to Subject and Goals	2(0)	3(7)	5(3)	3	4	3	7
Intro and Concluding Statements	5(1)	4(4)	1(5)	0	4	6	10
Transitions	0(0)	10(7)	0(3)	0	8	2	10
Conduct of Presentation							
Enthusiasm, Energy, Confidence	1(0)	6(4)	3(6)	0	5	5	10
Clarity of PowerPoint Slides	0(0)	9(2)	1(8)	0	2	8	10
Clarity & Precision of Explanations	5(0)	4(8)	1(2)	1	3	6	9
Voice (volume, speed, variation)	1(1)	7(5)	2(4)	0	7	3	10
Non-Verbal Communication	1(0)	7(10)	2(0)	2	7	1	8
Visual Aids (figures, tables, etc.)	0(0)	9(5)	1(5)	1	5	4	9
Questioning & Answering Questions	1(2)	4(0)	5(8)	2	4	4	8
Understanding & Contact w/ Audience	0(0)	9(6)	1(4)	1	7	2	9
Time Management	6(0)	1(0)	3(10)	1	2	7	9
Presentation Environment							
Room and Presenter Appearance	0(0)	10(4)	0(6)	0	4	6	10
Overall Assessment	**Tally: "Audience can summarize the main points of your presentation…"**			**Tally of Final Presentation Comparison for Overall Assessment**			**Number of Participants with Same or Improved Score**
	No	**Not Sure**	**Yes**	**Lower Score**	**Stayed Same**	**Higher Score**	
	0(0)	5(2)	5(8)	0	9	1	10

Conclusions

Based on the communications emphasis for the REU program at Cal Poly, the following conclusions were drawn:

- Incorporating communications emphasis for the REU program proved beneficial for developing student communication skills.
- Support of mentors and research faculty is important for providing broad feedback related to communications exercises.
- Guidelines for exercises and assessment rubrics have been developed and provided a highly structured framework for conducting the exercises.
- Integration of exercises that involved unconventional learning styles was central to the entire experience. These specific exercises provided opportunities for evaluating specialized communication skills.
- The improvement in student communication skills was attributed to the formal evaluation rubrics and the variety of feedback mechanisms. Progressive feedback to the students numerous times over the 10-week REU program was deemed critical in promoting and attaining improvement in the communication skills of the participants.

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Appendix - Communications Styles Assignment for REU Participants

Research Experiences for Undergraduates (REU) Site

Sustainable Management and Beneficial Reuse of Residual Wastes and Byproducts

Communication Style and Personality Type Exercise

Read the article on "Communication Styles" written by Marcy Villa and identify your own communication style, based on the survey results.

Reflect on your experience working with graduate students and faculty researchers during the first half of this summer program. Based on your understanding of communication styles, classify one graduate student (or post-doctoral researcher) and one faculty researcher/advisor as a Cheerleader, Computer, Medic, or Steamroller? Why did you select these communication styles? List three things you observed that support your conclusions for each.

Repeat this exercise for Myers-Briggs personality type. Again, justify your selections.

Graduate Student/Post-Doctoral Researcher:	
Communication Style:	Cheerleader | Steamroller | Computer | Medic
Justification for Selection:	
Myers-Briggs Personality Type:	
Justification for Selection:	

Faculty Researcher/Advisor:	
Communication Style:	Cheerleader | Steamroller | Computer | Medic
Justification for Selection:	
Myers-Briggs Personality Type:	
Justification for Selection:	

Appendix - Poster Presentation Tip Sheet for REU Participants

Research Experiences for Undergraduates (REU) Site

Sustainable Management and Beneficial Reuse of Residual Wastes and Byproducts

Research Poster Presentations

Presented below are guidelines, tips, and references related to research poster preparation. Thank you Kenzie! Please refer to this information as you prepare your posters. Please remember to consult with your research mentors during this process.

Guidelines

Poster Sections:

- **Heading**
  - Title
  - Authors (Include their titles, major/department, and academic institution)
- **Abstract** (optional)
- **Introduction**
  - Abstract (optional)
  - Justification/rationale - Why does your study matter? Who could benefit from your results? What is the "big picture"?
  - DO NOT only cite past literature that had promising results.
  - Purpose: What did you do?
- **Methodology**
  - Sample characteristics
  - Procedures: How did you collect the data?
  - Variables and measurement
    - List variable, scale, number items, response choices, and reliability
- **Results**
  - Analyses: Provide rationale for analyses performed.
  - Findings: Display in easy-to-read tables, bullets, and/or graphs.
- **Discussion**
  - Identify the most interesting findings and provide explanation/rationale for their occurrence. Are the results similar to past research? Does theory explain the findings? Did something about this data collection change the results?
- **Limitations** (optional)
- **Implications**
  - Based on results and limitations of this study, how might this inform future studies?
- **Acknowledgments**
  - Anyone who helped with the poster and/or the research (statistical advice, poster critique, fieldwork/lab help)
  - Funding sources
  - Conflicts of interest?
- **Important References** (as needed)

Formatting:

- **Poster Size: 36”x48”**
  - We will keep REU poster sizes consistent for comparison purposes.
  - Ref: http://www.posterpresentations.com/html/presentation_size_options.html)
- **Minimum Font Sizes**
  - ***Body*** text font size: 24
  - ***Title*** font size: 70 (72 pt preferred)
  - ***Text*** font size (used for captions, etc.): 18
- **Photographs and Figures**
  - ***Minimum photo/figure size***: 5” x 7”
  - ***Minimum resolution***: 300 dpi
  - Do not use web captures (that are typically of low resolution).
  - Crop photos to highlight important features.
  - Reference photos and figures that are not your own.
  - Think about composition when preparing all graphic elements.
- **Wording**
  - Do not overwhelm with excessive information; white space on poster is valuable.
  - Use phrases instead of sentences as much as possible.
  - Be sure to use:
    - bullets
    - appropriate grammar and spelling
    - active voice (not passive)
- **Design Programs**
  - There are several different programs available, but one of the most commonly used is PowerPoint. You may use whatever design program you would like, but your final poster must be a PDF file (modest size) for ease of printing and file transfer.

Presentation Tips

- Avoid visual chaos (boxes and fonts of varying size).
- Guide reader through poster using visual cues.
- Make it aesthetically pleasing. Use figures, diagrams, easy-to-read tables, etc.
- Be sure to use:
  - a program that allows you to print posters of the size recommended above
  - captions for all figures
  - sans serif for titles and headings
  - sans serif for body text
  - bulleted lists rather than paragraphs
  - italics instead of underlining
- There have been lots of conferences and lots of posters at each conference. Several examples are available to help you come up with an original, aesthetically pleasing, easily understood, and concise poster!

Useful Links

Referenced below are some great tips on poster sections, formatting, etc.:

< links omitted from example for brevity >