William Paterson University
College of Science and Health - Department of Computer Science

Fall 2015 – Spring 2017 Assessment Cycle
Analysis of the Program's Student Outcome Assessment Data

Program's Student Outcome:

S3: Demonstrate abilities to apply scientific methods to the discipline of computer science.

ABET's Related Student Outcomes: (i).

Assessment Committee Members: Gilbert Ndjatou (Chair), Bogong Su, Erh-Wen Hu

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A. Analysis of the Assessment Data

For the assessment period Fall 2015 to Spring 2017, this student outcome was assessed in CS4800. The variation from 20 in Fall 2015, to 21 students in Spring 2016, and then to 11 in Fall 2016 is easily explained by the fact that two successful semesters in a row can deplete the student supply temporarily, More important is the improvement attained as we progressed from 30 % to 9.5% and then to 0 % in the lowest achievement category of "Some Ability". To use the colloquial, "no student was left behind" and the standard was raised. Stronger outreach to those with the greatest need was accomplished. The rest of the 3 categories improved or remained relatively stationary (with a 10% fluctuation).

B. Suggestions for Improvement

This application os the Scientific Method to CS constitutes the most relevant aspect of the Scientific Method in terms of student appreciation of the methodology and in professional growth and benefit as their careers and graduate studies progress. It is the direct application to their discipline that will most indelibly influence their futures. Perhaps we can expand on the coverage and begin the process earlier in the course, maybe interleaving it with the ethics component. That would provide more time. One concern thought is the lack of support material in terms of web available pedagogical material in the form of formal hands-on activities (for students in class and as projects), more case-studies, more literature (presently just a handful of papers), and greater web availability for them (the Princeton site is effective and graciously provided but it is just one). Perhaps, a textbook dedicated to just this, preferably with a large problem set and experiments, with directions for further exploration.

C. Improvement Implemented

We need to continue this assessment model; while it has been proposed as a solution just about a 1-2 years prior to this implementation, it has proven successful, as students also incorporated it into their research and

project work. While students previously would test their software in an intuitive and hap-hazrd manner, now they are reasoning, actually experimenting, and inferring in a manner that returns the "Science" to Computer Science. Excelsior!

D. **List all the "performance level/frequency/percentage" tables and their sources.**

a. **Faculty Course Assessment Report: CS 4800, Fall 2015**

Data Collected: Examination scores from an exam given on applying the scientific method to Computer Science.

Method of Collection: Each student completed the examination on applying the scientific method to Computer Science. The exam consisted of 5 major long-answer problem-solving / essay questions which require hypothesis-forming, setting-up experiments to test hypothesis, conducting the experiments (AKA testing, harvesting data), interpreting the results to determine if the hypothesis is valid and can become a verified theory / "law" of CS.

Performance Levels	Frequency	Percentage
Some Ability	6	30.0 %
Adequate Ability	5	25.0 %
More than Adequate Ability	4	20.0 %
High Ability	5	35.0 %

Observations: This is the first semester we are applying the Scientific Method component as an aspect of CS 4800, as preparation for genuine research methodology and large-scale project work. While we had some of our top students on the high end, a comparable number of students were on the low end. We were a bit hurried in our coverage of this, partly because we transitioned to include the Scientific Method later in the course. This can easily be rectified by starting earlier and including the Scientific Method as a unified component of the research process and not as an after-thought. Students need time and more homework to be inculcated into an appreciation of the Scientific Method and applying it effectively. The first time is always fraught with disillusionment; the important lesson learned is to utilize this poor start to incorporate drastic changes and immediately rectifying the situation.
In the break between the semesters, I will collect-up more material and specifically those associated with Scientific Method as applied to Computer Science. This is a bit rare because programming is often treated as a linguistic domain of knowledge and not as a scientific process of inquiry. The terms "experiment" and "hypothesis formation" seem foreign to students in a programming context and with that type of background. We need a culture change, as the first computer scientists were actual scientists! While nostalgic, I foresee a set of lesson plans to realize this. This is not so much a problem as a challenge, to start a revolution (and all revolutions begin in the mind).

b. **Faculty Course Assessment Report: CS 4800, Spring 2016**

Data Collected: Examination scores from an exam given on applying the scientific method to Computer Science.

Method of Collection: Each student completed the examination on applying the scientific method to Computer Science. The exam consisted of 5 major long-answer problem-solving / essay questions which require hypothesis-forming, setting-up experiments to test hypothesis, conducting the experiments (AKA testing, harvesting data), interpreting the results to determine if the hypothesis is valid and can become a verified theory / "law" of CS.

Performance Levels	Frequency	Percentage
Some Ability	2	9.5 %
Adequate Ability	4	19 %
More than Adequate Ability	8	38 %
High Ability	7	33 %

Observations:
First, the Scientific Method component is a serious aspect of CS 4800, as preparation for genuine research methodology and large-scale project work.

The superb notes from Sedgewick at Princeton truly is a paragon of this domain of Science and the primary foundation: https://www.cs.princeton.edu/~rs/talks/ScienceCS10.pdf, titled: "Putting the Science Back into Computer Science". This was just perfect for the job and match my own prior and independent perspectives on the subject and the testing model.

I coupled this with several fine papers internationally on this area and some on Engineering Design applied both to Hardware and Software. I even observed that Security has been studied (in terms of CS educational research) using the Scientific Methodology, as in:
http://web.cs.ucdavis.edu/~peisert/research/Peisert-WISE2007-SecurityExperiments.pdf

Actually, we were strongly influenced by Jon Bentley's presentation in 2015 on "Experiments with Algorithms" given at William Paterson University. We are deeply blessed to have him on campus and so active in our Advisory Board as well as our departmental community.

Students did quite well on the Scientific Method and its application to CS.

Independent Observation and Recommendation:
Students taking General Biology 1 and 2 were getting high levels of DFW's (i.e. grades of D (minimal passing), F (failure), and W (withdrawal)). This is based on comments from the Biology Department, compiled from their assessment statistics. As General Physics and Chemistry more directly relate to CS and the scientific methodology needed for CS is more directly (and extensively) covered by them than in

General Biology, I recommend we move General Biology 1 and 2 to Additional Math/Science rather than keeping them in General Science 1 & 2 category. This was confirmed by discussion and observations with students in CS 4800. I also discussed this with CS faculty and found some degree of consensus. We used to (decades ago) require Physics alone but that is too narrow for now; other universities also show preference for Physics and Chemistry.

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c. **Faculty Course Assessment Report: CS 4800, Fall 2016**

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Performance Levels	Frequency	Percentage
Some Ability	0	0.0 %
Adequate Ability	3	27.3 %
More than Adequate Ability	4	36.4 %
High Ability	4	36.4 %

Observations:

First, the Scientific Method component is a serious aspect of CS 4800, as preparation for genuine research methodology and large-scale project work. Four of the students among our top students and strongly devoted to academics and independently produced the 4 High Ability cases in this examination (logical and expected). The top two were mentioned above in the prior section of this report for best presentations as well; the second two of the four are also A students but slightly slumped in their senior year (partly attributable to full-time jobs, as this is a late night -section). All four did excellent work on this exam.

The exam had a blend of Scientific Method applied to several areas of CS.
One area was hardware design (using Scientific Methodology).
Another was in debugging/testing (i.e. I gave faulty code random shuffling-code and they needed to determine which categories / cases were not generated by the sampling, inference, hypothesis-formation, experiment, testing, interpetation, and final analysis processes).
A third question was an empirical analysis of an algorithm, to determine complexity of a program which I gave. Students had to do hypothesis-formation, runs/experiments (using randomly generated data), then collecting statistics over larger input sizes, drawing inferences / interpreting the results, and final confirmation.
Two more problems rounded out the exam, with 20 points for each question.

To prepare students (besides the 4 Science courses required in the curriculum), we also reviewed CS specific application of the Scientific Method in this class. The superb notes from Sedgewick at Princeton truly is a paragon of this domain of Science and the primary foundation: https://www.cs.princeton.edu/~rs/talks/ScienceCS10.pdf, titled: "Putting the Science Back into Computer Science". This was just perfect for the job and match my own prior and independent perspectives on the subject and the testing model.

I coupled this with several fine papers internationally on this area and some on Engineering Design applied both to Hardware and Software. I even observed that Security has been studied (in terms of CS educational research) using the Scientific Methodology, as in: http://web.cs.ucdavis.edu/~peisert/research/Peisert-WISE2007-SecurityExperiments.pdf

Actually, we were greatly influenced by Jon Bentley's presentation in 2015 on "Experiments with Algorithms" given at William Paterson University. We are genuinely blessed to have him on campus and so active in our Advisory Board as well as our departmental community.

Students did quite well on the Scientific Method and its application to CS. Even better than the Spring 2016 semester.

Independent Observation and Recommendation:
Students taking General Biology 1 and 2 were getting high levels of DFW's (based on comments from the Biology Department). As General Physics and Chemistry more directly relate to CS and the scientific methodology needed for CS is more directly (and extensively) covered by them than in General Biology, I recommend we move General Biology 1 and 2 to Additional Math/Science rather than keeping them in General Science 1 & 2 category. This was confirmed by discussion and observations with students in CS 4800. I also discussed this with CS faculty and found some degree of consensus. We used to (decades ago) require Physics alone but that is too narrow for now; other universities also show preference for Physics and Chemistry.

The scientific method is the focus of ABET, as a process for inquiry/reasoning, and, ultimately, how it is applicable in contributing to CS. As such is the criterion, Chemistry and Physics provide more requisite, relevant, and applicable foundations, principles, and methodologies. This should resolve any concerns or any distress caused by CS student misinterpreting General Biology domain of coverage and avoid further problems for all constituencies involved (including Biology) while improving documentation used in directing and advising those students towards optimal education and professional growth.

This will not affect Additional Math/Science, which has more choice and can be used by transfers and ex-other majors who go into CS (i.e. those who already took Biology courses). However, we should consider tiered listings of those Additional Sciences in that list as well. The ordering will prioritize or recommend the most relevant (to CS) courses first (such as Electronics). List order is often interpreted by students as being an indicator of preference