Future of Undergraduate Geoscience Education

Summary of Departmental Progress

The 2016 Heads and Chairs Summit on the Future of Undergraduate Education had 114 participants from community colleges, BA/BS four year colleges, masters granting institutions, Ph.D. granting universities from R3/DPUs to R1s, plus an NSF, industry, and two professional society representatives. Before leaving the Summit, participants submitted action plans for their individual departments. Some universities had multiple attendees, including panelists and organizing committee members, who worked together on the action plans for their institution. From these Summit efforts, 79 action plans were generated. The 2017 Earth Educators Rendezvous (EER) had 34 participants. Of these 14 had been to the 2016 Heads and Chairs Summit and had submitted an action plan progress report by the summer of 2017, and one also submitted a follow-up report in May 2019. For the heads/chairs that had not been to the previous summit, 12 submitted an action plans and 4 submitted a progress report in 2019. A second request was made in 2020. Several institutions had multiple participants and two participants were observers (NSF, SERC) and two did not submit action plans.

Overall between the Heads/Chairs Summit and EER workshop, we received 91 individual department action plans. A total of 56 participants provided feedback regarding the progress their departments had made toward reaching their Action Plan objectives (62% return), mainly between 16-18 months afterward the Summit or Workshop, however 3 from the workshop were submitted after 2 years, and 5 from the summit after 3 years. A follow-up progress report was submitted by 11 in 2019 about 2 years after the first one, and by one in 2020 after 3 years. These later and updated reports help show the overall timeline needed for making change in undergraduate programs. The responses span the range of participating institutions (5 2YC, 9 BS/BA only, 11 Masters only, 14 Ph.D. R2/R3/D/PU and 25 Ph.D. RI institutions).

To identify best practices and common problems and solutions, we asked the following questions:

- How much progress have you made with your plan? If you have modified your plan since then, in what way did it change and why?
- What has been accomplished, whether it was in your original plan or not?
- What are your future plans?
- Which implementation strategies worked – i.e. what was successful, and what wasn't?
- What were roadblocks to progress or where did problems occur? And if you were able to overcome them, what did you do?
- What did you anticipate would be a problem that wasn't?
- Any advice to others who wish to make similar changes?

Below, their progress is reviewed both objectively and subjectively to identify trends among departments.

To describe their progress objectively, their feedback was quantified using a rubric (provided at end of appendix) designed to evaluate the common themes identified in the workshops - curriculum redesign, increase in an active learning-based pedagogy, 2YC to 4YC transfers, recruitment of underrepresented groups, adding new courses and adding/deleting majors. Curriculum redesign and increased implementation of active learning require the greatest amount of time and active engagement by faculty so therefore carried more weight when progress was being evaluated. (Not all participants proposed to address all six themes.) Additionally, the objectives of action plans varied in detail and magnitude. Some of the smaller institutions had very specific action items such as 'rework an introductory geoscience course to improve recruitment and retention' or 'increase lab space and

technology access' while the larger departments proposed a complete curriculum overhaul by producing backwards design matrices, planning retreats and final adoption of curricula. Finally, in terms of updating progress, some departments reported very specific accomplishments, for example they "created a Mogk-style matrix for each of three majors, identified gaps and rewrote curricula". Others reported progress in more general terms, such as "our plan has been largely implemented" without commenting on process or specific outcome.

When taking into consideration the specificity of Action Plans coupled with the variation in reporting style, the overall trend is that *the fewer the number of geology faculty in a department the more they had progressed toward implementing their plan* (Fig. 1). When 'Carnegie classification' is considered, 2YC, BA/BS and MA/MS institutions made more progress than R1 and R2 institutions, even when R1s and R2s had equivalently small faculty sizes.

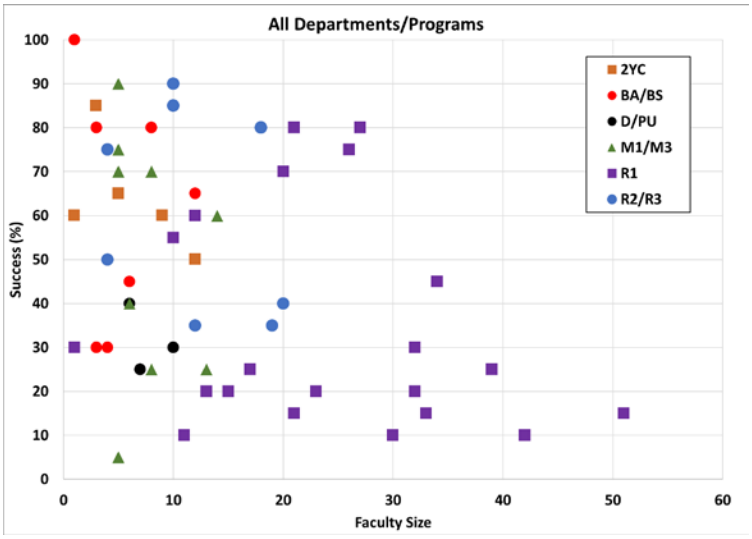

Figure 1. Success of action plans by faculty size and institution type

In some departments, the slow rate of progress was attributed to common factors such as lack of faculty buy-in and bureaucracy (curriculum approval, funding for new faculty, lab space, equipment, etc.). Eleven departments had begun a campus or state-mandated curriculum overhaul before the first Summit or workshop, so they were already a few years into the process when they attended. As is evident from the chart, where faculty size exceeded 27, departments did not make more than 50% progress. Although faculty numbers between 5 and 10 appear to be most successful, too few faculty was a challenge as they were spread too thin to pursue a deep dive into curriculum redesign and to engage in new teaching methods. Their focus was primarily on recruitment/retention and 2YC to 4YC transition. Had departments had more time or if they had already begun curriculum revisions, they likely have made more progress.

Twelve departments submitted a second progress reports and all but two reflected more progress, primarily because they had more time to achieve results. Common themes from those who provided 2019 updates to their 2017 progress reports:

- (1) Change is a continuous process that requires patience, (2) the ones who sent updates generally had a defined vision and stewarded progress against that vision, (3) short-term goals and tactics were continually updated in response to internal/external changes – university mandates, staff changes, etc., (3) over the 2-yr period, departments had commonly focused on one aspect of their plan, (4) continuity of champions was an issue for those who didn't make much progress.

- Five Ph.D. granting institutions are good examples of developing vision, empowering others to act on vision, addressing obstacles, finding short-term wins.

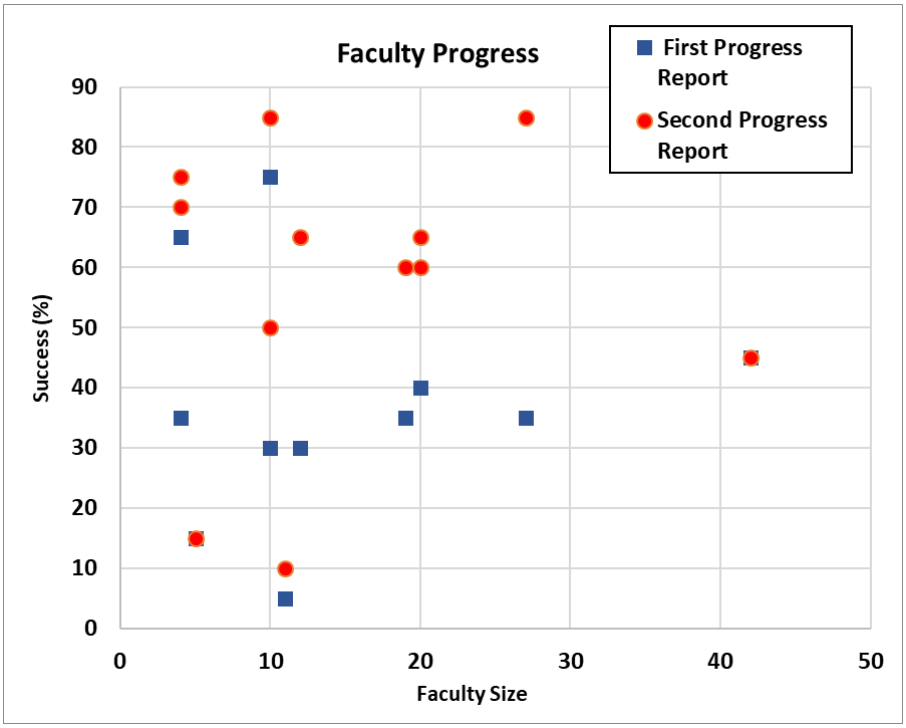

Figure 2. Changes in success rate over time.

Institution: **Carnegie Classification**	**Faculty Size**	**Progress (1^{st}/2^{nd})**
BS public	4	65/70
M1 public	4	35/75
M1 public	4	35/75
M1 public, MSI/HSI	5	15/15
D/PU public	10	75/85
D/PU public	10	30/50
R2 public	19	35/60
R2 public; MSI/HSI	20	40/65
R1 public	20	40/60
R1 public	11	5/10
R1 public	27	35/85
R1 public	42	45/45

From a more subjective perspective, many of the departments shared similar experiences in terms of successes and challenges. Collegiality, support of leadership, department retreats and the use of SERC-endorsed resources contributed to successes. Many were constrained by outside forces such as limited campus budgets, hiring freezes and low enrollment. No matter the department size, many departments had to contend with faculty who were unwilling to change traditional curriculum or adopt new pedagogy, but with persistence many succeeded. More details are provided in a later section.

Elements of Success

The graph clearly shows that for faculty size greater than 20 (all R1s) and for those less than 20 (all types) some were more successful than others, leading to the following questions:

(1) For the four R1s with 20 or more faculty that were over or at 60% successful – what did they do that was different? Why were they successful? What part did they primarily distinguish themselves doing – i.e. was it redoing the curriculum, changing pedagogy, etc.

R1, >20 faculty, > 60% successful: Two of four departments submitted two progress reports (one improved from 40% to 60% and the other from 35%to 85%):

All four redesigned their curriculum using the backwards design matrix approach. Only one of the four substantially addressed pedagogy. Two provided dedicated time for a faculty member to work on program changes.

Additionally, departments noted:

- increased a faculty member with a 9-month appointment to 12-months for the purpose of focusing on career-building exercises for students;
- granted a faculty member a teaching release so that she could dedicate attention to writing new curriculum and submitting it to the campus for approval;
- involved early-career faculty;
- implemented new peer teaching evaluations;
- implemented training course for grad students to improve TA support of new active learning courses;
- considerable sharing of course syllabi among faculty to minimize overlap in prerequisites and core courses;
- produced fully developed matrices at a retreat devoted to this purpose and attended by all faculty;
- many major courses were flipped;
- assessing outcomes (to show success!) via campus mandated degree assessment.

(2) Same questions for the three R1s with more than 20 faculty that were between 40-50%. And for the 3 R2s with close to 20 faculty and over 60% successful?

R1, >20 faculty, 40-50% success (3 departments, 1 of 3 provided two progress reports but did not make progress between the two):

- curriculum effort was driven by a few faculty with a bottom-up approach rather than top-down;
- moved very slowly (took four years) and took time to get feedback from all faculty to assure support;
- in terms of pedagogy, one department supported professional development for teaching.

R2, ~20 faculty, > 60% success (3 departments; 2 of 3 provided two progress reports improving from 35 to 60% and 40 to 65%):

- encouraged faculty to engage classes with more active/experiential learning exercises;
- did much of work at a retreat (2 departments);
- began process of restructuring the department with goal of sharing courses across curricula (geology, geography and environmental science);
- Backwards design matrix was instrumental in identifying gaps;
- pairing courses throughout the undergrad trajectory for students to see connections and afford opportunity to work on projects as teams;
- streamline programs/courses to assure they reflect what the department has the expertise to teach.

(3) For all with smaller faculty (under 20) and over 60% successful, was the success primarily because of major curriculum or pedagogy changes or was it all the other types of things, like e-portfolios or increasing some skills/concepts like more communication, etc.

Of the 19 departments:

- One-third of them had already begun curriculum redesign prior to attending workshops which boosted their progress (6 departments).
- More than half made changes to pedagogy (11 departments).
- Less than half tackled other areas such as 2YC-4YC transfers (7 departments), improving recruitment and retention (6), adding new courses (4), incorporating e-portfolios (2) and making changes to majors (4). Most of the departments that tackled these other areas fall in the 5 to10 faculty range. (*See below for specific departments).
- Three of the four 2-Year colleges did not propose to make curricular changes at all and while they may have done some tweaking, their progress was based on improvements focused primarily on recruitment/retention and transfer to 4-year programs.
- Hosted an NAGT Traveling Workshop, "Building Stronger Geoscience Departments".

***Faculty <20 faculty and >60% success, areas outside of curriculum and pedagogy:** Most of the departments that tackled these areas fall in the 5 to10 faculty size range.

2YC-4YC transfers:
7 departments - 2CC, 2BS/BA, 2M1, 1R3/D/PU
Improved recruitment and retention:
6 departments – 3BS/BA, 3 M1
Added new courses:
4 departments - 1BS/BA, 1M3, 1M1, 1R2
Incorporated e-portfolios:
2 departments – 1BS/BA, 1R3/D/PU
Made changes to majors:
4 departments – 2BS/BA, 1M3, 1M1

(4) Are there any strategies that clearly were a major failure – not including budget cuts, upper administration issues, etc.?

No, no major failures. Instead of sweeping curricular or pedagogical improvements, one R1 department put a lot of energy into a proposal aimed at improving relations with local two-year colleges that did not get funded. It did, however, build a relationship with the science education department.

<u>Successful Strategies</u>

An additional analysis based on a set of questions provided the following information:

(1) How useful were retreats?

Extremely. Not one reported failure. Nine departments planned retreats and seven had executed before their last progress report:

- 2YC (0)
- BA/S (1) –*one planned.*
- M1/M3 – (2) Most helpful for curricular revision was two-day workshop - developed the very specific action plan with faculty names and deadlines attached for each task. *One planned*.
- D/PU (1) - Two-day retreat with facilitators from NAGT's Traveling Workshop Program was very much a success.
- R2 (3) –Where the most progress was made.
- R1 (3) –SERC pages on retreat planning very helpful.
  All-day retreat was REALLY worthwhile – did it all the way across campus with meals catered. That bought eight hours x 40 faculty required to get the basic data, which a smaller group of staff and leadership could then use to create the final matrices.
  Successful Friday afternoon faculty retreat to discuss curriculum map. *One planned.*

(2) How useful was doing the backwards design/matrix?

Fifteen of forty-eight departments that addressed curriculum specifically referenced the matrix approach or backward design.

- 2YC (0)
- BA/S (0)
- M1/M3 (4) –One department brought in David Mogk to present a seminar and afternoon workshop on curriculum planning and content.
- R2/R3/D/PU (6) – Backward design or matrix used.
  Constructed a matrix of undergraduate course competencies/skills. Posted the matrix online and faculty identified which are taught in their courses and which should be added to undergraduate curriculum.
  Matrix identified major gaps (however 50% of faculty either misinterpreted or neglected request for input).
- R1 (7) - We collected syllabi and materials and met individually with all faculty to verify which outcomes and skills were met by the course and at what level (basic, enriched, reinforced). We have assessed our outcomes (one course per year) via mandated degree assessment from the University starting with GEOL 101 and moving up through the curriculum.
  Matrix identified gaps in quantitative skills and math.
  Major curriculum revision in 2014 lacked a formal document to identify which concepts, skills, and competencies are covered in the new curriculum so retroactively developed such a metric.

(3) What kinds of things made changing to more active learning pedagogy easier?

In general, attending workshops (SAGE, Earth Educators' Rendezvous); open faculty discussion and sharing of resources; enthusiastic junior faculty; positive outcomes supported by student assessment; and introduction of new ideas at retreats.

More specifically:

- 2YC (4): Explore topics through investigation using physical samples and models plus technology using large data sets, interactivity, animations and video instruction.
  Successfully transitioned to a flipped classroom model for introductory course which focuses on active learning vs. passive listening.
- BS (1)
- M1/M3 (2) Progress establishing the importance of successful adoption of active-learning in courses as a faculty performance expectation.
  Two geoscience faculty were instrumental in establishing a college FAST Team (Faculty Advocates for STEM Transformation) that is working to showcase active-learning pedagogies and to provide professional development.
- R2/R3/DPU (3): Incentivized our merit review process to reward faculty who develop and implement reformed teaching methods that incorporate engaged learning.
- R1 (4): Peer mentoring in active-learning introductory classrooms. We have "new" faculty co-teach these courses with seasoned instructors and then take over the course as lead instructor after 1-2 semesters. With help of teaching post doc introductory lab course was "flipped" and Mineralogy, Geochemistry and Biogeochemistry are all major courses that have been "flipped".

  Identified intro level courses taken by all majors that make them ideal candidates for innovative instructional methods such as the flipped classroom and blended learning. Seeking new faculty hires who have experience in innovative instructional methods, and encourage new faculty to bring new and creative methods to our department.

  3 faculty have been supported to undertake professional development for teaching and 3 more have been supported in developing experiential international courses. Chair attended a SAGE workshop where some pedagogical methods were summarized and demonstrated.

  Recognizing that classic or traditional freshmen geology classes are becoming less attractive, we were motivated to be proactive in what we teach and had the willingness to do our best to offer a modern geology courses in our curriculum.

(4) Were there specific comments about using the employer's recommendations for concepts and skills or the Summit outcomes being used to demonstrate what needed to change (either course content/courses or incorporation of skills)?

Yes, some examples:

- BA/S – All elective courses focus on developing skills and conceptual understandings valued by industry, including quantitative, written, conceptual and technical skills.
- M1/M3 –Sharing summaries from the Summits, along with the employer-vetted concept and skills matrix, helped greatly with faculty buy-in.
- R2/R3/D/PU – Focused on streamlining student learning outcomes and methods of assessment by integrating more critical thinking, writing, presentation skills, and teamwork into existing classes. There has also been a concerted effort to encourage faculty to engage classes with more active/experiential learning exercises.
  Curriculum that stresses repeated exposure and expected mastery of key skills necessary for conducting research, reporting research (oral and written), analyzing data and designing research plans.
- R1 – Emphasized topics such as experiential learning and field instruction rather than specific content.
  Discovered had placed much of the transferrable skills in specific classes (e.g., writing, in one course titled Scientific Communication) which meant students would get these skills once, but

maybe not again. Alpha-testing infusing these transferrable skills into the majors courses (e.g., writing exercises, taught by a second instructor who specializes in scientific writing, embedded in the context of an exercise in Structural Geology).

(5) Any mention of addressing specific skills (quantitative, communication, field, etc.) in their curriculum?

Yes, in addition to the previous question:

- 2YC - purchase of E-science lab kits geared toward testing and measuring/analyzing hypotheses.
- BA/S - Intentionally embedding science communication into key parts of the curriculum, helping students to increase their capacity for effective written, oral, and graphic communication to both scientific and non-specialist audiences.
- Produced a 'Geology Roadmap' given to all majors that outlines discipline-specific skills and student learning outcomes.
  Although a set of content-specific courses, new program represents a collective, conscious shift of focus toward building core student competencies and "must-have" skill sets in addition to content-driven knowledge base. Placing an even greater emphasis on students using, applying, communicating and being innovative with what they've learned.
  To expose students to research invoke more research-like experiences earlier in the curriculum to bring all students to a higher level of readiness.
  Integrating more critical thinking, writing, presentation skills, and teamwork into existing classes.
- D/PU – Developed an Earth Science Professional Development Seminar course for all Earth Science majors. The professional development course helps students become aware of career prep resources on campus and in the discipline, learn to write resumes, practice interviews via video conferencing, etc.

(6) How many worked on 2YC to 4YC transfers – how many had success?

10 departments made progress, from building relationships with institutions to the following:

- 2YC (3) – inviting 4YC faculty to field trips for one-on-one time with students; student panels and socials for discussing transfer options.
- M1/M3 (2) –13 new transfers into 4YC in one summer.
  Hosted a conference for state system campuses and was well-attended by 2YCs.
- R2/R3/DPU – (3) multiple summits with area 2YC instructors.
  Submitted NSF Pathways grant for connection with 2YC (not funded).
  Completed articulation agreements for the Geology degree with 4 local two-year community colleges are nearly done with a fifth agreement. We have continued to work on strengthening our connections with those two-year colleges.
- R1 (2) –Developed a transfer pathway/academic map for students transferring in from 2YC.
  Developed freshman field exchange with local CC geology faculty.

(7) How many reported on recruitment and retention of underrepresented minorities or recruitment/retention overall? Any specific examples of success?

8 reported on recruitment and retention. Some success stories:

- 2YC – (1) faculty attendance at campus outreach events for international students and veterans.
- BA/S – (4) To increase retention of first gen college students, designed a 1-credit course that includes problem-based field and lab activities, discussions, and visits from alumni and industry-

professionals. Students will leave with a clear path to graduation, an outline for a portfolio and resume, and knowledge of various career opportunities.
Focus on messaging with Admissions office recruiting and advertising materials; inclusive of disparate levels of science background.
50% faculty now from underrepresented groups; active learning helps retention.

- M1 – (1) student mentoring/support for diverse students; collaboration with other STEM departments.
- R2/R3/DPU (2) –Presentations during introductory classes informing students about the Geology major and employment opportunities.
  A key part of the IUSE GEOPATHS grant, the undergraduate research cohorts, has been successful with a substantial increase in the number of B.S. graduates going on for graduate work, including 3 students from underrepresented groups (African-American and Latina). All of those who went on for graduate work were connected in some way to the research cohorts.
- R1 (1)

(8) How many reported on K-12 teacher training, how many successes, what type of institutions did this (i.e. # of each)?

Only two

- 2YC (1) - Admin focus.
- BA/S (0)
- MA/S (1) – hoped to link matrices to Next Gen Science Standards for benefit of science education students but received huge faculty blowback (currently working on link to concepts/competencies/skills as well as ASBOG Fundamentals instead).
- R2/R3 (0)
- R1 (0)

(9) How many talked about working with employers? Note – not necessarily in many action plans.

Very few.

- 2YC (2) – worked with local museum and city government for internships.
  Local community organizations have created undergraduate research opportunities for students in a service learning capacity.
- BA/S (1) –bringing in industry representatives to discuss career paths.
- M1/M3 (3) – Representatives from the State Board (that employs many geoscientists) spoke to faculty and students in representing competencies vetted by employers.
  County Water Dept. for paid internships and fieldwork.
  We have shared the matrix with our advisory board and they have provided feedback related to the workforce skills need in their particular segment of the geoscience workforce.
- R2/R3/D/PU (1) – The “Career Track” will prepare students for graduate school or employment in the field of geosciences. The “General Track” provides the student with a solid background in the geosciences, however it is probably lacking in some of the cognate courses (specifically Calculus, and less rigorous Chemistry and Physics). Second track was developed for students who enjoy geology but may end up working outside of the geosciences.
- R1 (1) Our Advisory Council (consisting of employers) reviewed and discussed the Summit series outcomes and were in general agreement with the results. We continually work with employers of our students with them providing students career and interviewing advice, giving professional talks and providing datasets.

(**10) How many used e-portfolios**?

Four total:

- 2YC (0)
- BA/S (1) – students in a single credit 'career path' class outline an ePortfolio.
- M1/M3 (0)
- R2/R3/D/PU (4) – department developing an ePortfolio template to illustrate mastery of each competency/skill which will also include a student reflection component.
  Used ePortfolio assignments to assess student achievement of more specific geoscience knowledge and skills, such as those identified by the Summit participants.
  AY2019-2020 implemented requirement that all students in specific Geoscience courses complete a 'signature assignment' to be uploaded to an ePortfolio. At the end of each semester, student ePortfolio 'signature assignments' are assessed on several specific criteria. A university-provided rubric was used as a rating tool for ePortfolios. A small financial incentive (paid by the university) to faculty willing to implement the ePortfolio requirement in their courses.
  May add an "ePortfolio" based on competencies as a capstone requirement.
- R1 (0)

(11) Any comments on assessment strategies?

Yes, 15 include the need for assessment in their plans but only a handful offer successful strategies:

- 2YC (0)
- BA/S (3) – Challenged with annual assessment exercises because although learn what graduates know, it's not clear where in curriculum they learned it.
  Faculty have been asked to assess WOVN - Writing, Oral, Verbal, Numerical – in every course. Also, add these questions to annual performance review: What do you do? What have you tried? How do you know that changes you make are better? Are you still teaching what students can look up? Chair included the first three questions in performance and course reviews AY 2016-17. The last question will be added to course and performance reviews in AY2017-18 in coordination with better implementation of introducing active learning methods.
- M1/M3 (3) – Generating questions for an exit interview for graduates.
- R2/R3/D/PU (3) – Considering replacement of University-provided rubric used for ePortfolio assignments to assess student achievement with more specific criteria identified by the Summit or combine the two.
  Assessment resulted from merging of our original plan to use ePortfolio assignments to assess student achievement of more specific geoscience knowledge and skills, such as those identified by the Summit participants, with the University's new Quality Enhancement Plan (QEP).
- R1 (6) –Looking at alternative assessment (pre-post- test in all courses—bridging between previous and next course in the sequence).
  Developing a database of what graduates do in terms of jobs, further education, and careers but challenge to obtain necessary contact information from the administration.

<u>Progress Reports Summary</u>

Six major themes were identified in the progress reports: changes focused on (1) curriculum redesign, (2) pedagogy, (3) promoting 2YC-4YC transfer, (4) recruitment and retention of underrepresented groups, (5) changes to the major, and (6) changes (addition/deletion) of courses. Progress reports are discussed according to institution type (2YC, BA/BS public, BA/BS private, MA/MS

granting institutions, DPU, R3, R2, and R1. The following summarizes the experiences of the different departments in implementing their action plans, which strategies promoted progress, what were the challenges and roadblocks that impeded progress, and any advice.

Five 2YC institutions range in faculty size from 1-5:

A total of 5 two-year colleges submitted progress reports in 2017 and another one in 2019. Of these, one institution has plans to implement a **curriculum redesign** assisted by a departmental matrix. With respect to changes in **pedagogy**, 4 of these institutions have made progress through the implementation of service learning, flipped classrooms, open-access educational resources, and competency-based review. In addition, interest in pedagogical changes have resulted in increased participation in faculty professional development. One of the 2YC's mentioned increased **collaboration with four-year colleges**, which resulted in new learning outcomes and partnership with environmental (rather than just geology or earth science) programs. The 2019 report mentioned importance of collaboration with the community for internships, other student opportunities.

<u>Successes and Strategies</u>

Developing relationships is critical for transitioning students to 4YC. Invited faculty members from possible transfer universities to campus or on field trips for students to learn about future opportunities.

Connecting our students with internship opportunities is important. A grant supported students from a community college to work the summer with UNAVCO in Boulder.

Collaborating with the community, including a local museum and city government, increases outreach and education beyond community college's walls. This, of course, improves recruitment and retention of students.

<u>Challenges and Roadblocks</u>

A large part of the focus is on teacher education and training, which is a positive outcome but can deter efforts to produce successful geoscientists (curriculum design, learning experiences).

University-wide budget issues caused a hiring freeze.

Time is the greatest barrier--a lot of these changes require time to write, propose, collaborate, etc...other duties have to take priority (2 departments).

<u>Advice</u>

Just hang in there – follow highs and lows of budgets and dynamics of leadership with their own goals for campus success.

Developing relationships is critical. We had a weekend field trip and invited a faculty member from the transfer university to attend. Having that unstructured time for majors to ask her questions was invaluable.

Obviously "be the change." You have to model the change for others to see what works. And don't be afraid to ask what others are doing in their classrooms. Encourage them to make student-friendly decisions.

Six BA/BS institutions range in faculty size from 3-12:

BA/BS institutions that submitted progress reports include 6 institutions, with between 12 and 4 faculty (with an average of 6 faculty). Two of the institutions sent 2019 updated progress reports focusing on the need to evaluate how effectively the changes are serving students. Of these

institutions, 5 worked on **curriculum redesign** -- Electives were modified to add competencies, and some courses were eliminated. Learning outcomes were added; science communication was emphasized; a roadmap for majors was created; more common core courses were required, and a shift to competencies and skills occurred. Other institutions still have plans to reconfigure their curriculum. Major advice regarding curriculum changes include: work on big picture engagement and agreement through communication and dialogue, and course level change is difficult, even with big picture agreement. One of the major strategies was to allow the younger faculty take lead.

Four institutions made progress on **pedagogy** changes, with the introduction of more active learning techniques and more focus on measurable outcomes and assessment. Faculty discussions, departmental retreats, and increased participation in teaching workshops were instrumental in facilitating these pedagogical changes.

None of the BA/BS institutions worked on **2YC-4YC transfers**. Four of these institutions worked on promoting inclusion of **underrepresented groups.** A new seminar course was designed (but not yet implemented) to aid in retention. General outreach efforts, as well as specific effort to make the department more accessible for students with varying levels of science readiness, were enacted to work on recruitment. Strategies included faculty involvement directly in the retention and outreach efforts, as well as active learning as a means of promoting retention.

Two institutions worked on **changes to majors**, introducing a cross-disciplinary BS in geobusiness, a new environmental geology degree, a new geophysics major, a non-thesis MS in Environmental Science, and new certificates. These new initiatives were helped by focusing on cross-disciplinary degrees, and through work with faculty and directly with the academic vice president. One institution worked on changes to **courses**, adding a statistics and a GIS course.

<u>Successes and Strategies</u>

Faculty receptive to programmatic changes.

Overall faculty engagement. – i.e. understanding the difference between course assessment and student assessment.

Defining the big picture in terms of incorporating a competency based approach.

Established a new Geology program - although on paper it is a set of content-specific courses, it represents a collective, conscious shift of focus toward building core student competencies and "must-have" skill sets and attributes in addition to content-driven knowledge base. Now placing greater emphasis on students using, applying, communicating and being innovative with what they've learned. The new program design now fills more gaps and contains more purposeful scaffolding.

We led an effort with the business and math departments to propose a new cross-disciplinary B.S. degree in GeoBusiness and Data Analytics. Students take core geology classes and courses in business, economics, statistics, big data management, spatial data analysis, programming, and technical writing. The integrated skill set developed was viewed by our advisory board and other industry experts as very strong and employable. The Academic Vice President sees it as an innovative degree that will prepare students for the business workforce and for non-geology graduate work (MBA, geo-economics, etc.); he is encouraging other departments to consider similar cross-disciplinary degrees.

Many of our students have an interest in geospatial studies so we created a B.S. degree that builds on that interest that includes core geology classes as well as earning a certificate in GIS and a

certificate in another technical field including computer programming, web design, networking, or data science. Graduates with this degree have found immediate employment.

Leveraged annual program review and mapping core competencies onto departmental and institutional learning outcomes and constructing a competencies matrix to make sure that students acquire core competencies and desired skills through our program.

Existing curricular map was evaluated. As a department we agreed that all elective courses should focus on developing skills and conceptual understandings valued by industry, including quantitative, written, conceptual and technical skills.

Student assessment will be added to course and performance reviews in AY2017-18.

Our network with internship-granting agencies has grown and more students are taking internship for credit. Also, some members of our faculty are part of a state-level team attempting to launch a state system-wide geology field course for Geology students at the 14 universities.

In response to historically low graduation rates, we designed a 1-credit *'active learning' class* during which students design a clear path to graduation, an outline for a portfolio and resume, and are exposed to various career opportunities.

To meet the needs of students of varied interests and backgrounds, we developed an Environmental Geology degree and worked with a nearby university to create a *non-thesis 4+1 M.S. option in Environmental Science*. Early measures of this degree suggest about 70% of graduates will go, or have gone directly into industry, and about 20% are interested in graduate school.

University-mandated reduction of classes with low enrollment resulted in reducing elective courses from nine to six. The remaining six electives strengthened their focus on developing skills and conceptual understanding valued by industry. (Direction from above contributed to the outcome.)

<u>Challenges and Roadblocks</u>

While colleagues were very receptive to programmatic "big picture" changes, affecting what they do in the classroom is much more difficult.

Quantitative assessment is tricky. Often it seems as if a new active-learning activity is ephemeral, the students feel good about it, they enjoy it, but there is little to no improvement in the overall learning in the class.

Implementation efforts were derailed by bureaucratic forces and the limits of smaller faculty size. Of the three full time faculty, one retired and the college will not authorize a replacement which leaves the remaining two to cover all department duties.

State budget cuts and declining enrollment preclude funding for professional development even though senior administration is aware of the need to incentivize teaching.

Biggest obstacle remains a budget shortfall and a decade of plummeting enrollment.

Progress has stalled because of major budget constraints due to declining enrollment.

<u>Advice</u>

Open dialogue and communication within the department is key.

Leverage institutional processes, such as regular Program Review, to drive change.

Add these questions about teaching to annual performance review: What do you do? What have you tried? How do you know that changes you make are better? Are you still teaching what students can look up?

The nine M1 and two M3 institutions range in faculty size from 4-14:

Seven MS/MA institutions submitted 2017 progress reports. One of those institutions one submitted a minor 2019 update, and 2 institutions submitted new reports, for a total of 9 MS/MA institutions reporting. Eight of the nine institutions made progress on **curriculum redesign.** Progress included revisions to courses and curriculum, related to an NSF-IUSE project; increase resources to add engineering geology and geophysics programs; and development of a curriculum matrix combined with internally developed Knowledge, Skills, and Dispositions work. Additional changes include design of upper-level courses to fill gaps, improved internship and undergraduate research opportunities, collaboration with a civil engineering school to design a 3-2 curriculum to recruit students with stronger math backgrounds; and addition of physics, math, GIS, surface processes and field components. Future efforts include a department retreat to help guide curriculum change, new faculty hires; and updates to BSc with more focus on workforce skills. Progress was possible with faculty who are motivated to make changes, collaboration with other departments, and capitalization with internal experiences and NAGT site visits.

Progress related to **pedagogy** includes faculty mentoring and peer evaluation, adoption of active learning as a faculty performance expectation. Other progress includes: newer faculty are working with a geology lecturer to build reformed (active) teaching modules. College-wide effort to increase active learning in STEM departments. Faculty developed team to work on showcasing these pedagogies and providing professional development.

Two institutions are working on **2YC-4YC transfer**, with 2YCs visiting to develop a pathways document and to attend a meeting on community consensus vision. One institution reports that these efforts have led to noticeable improvement in attracting 2YC students to program. 2YCs have been involved in conversations regarding skills, competencies. These MA/MS institutions advise to build strong relationship with 2YC faculty (faculty-faculty > administrator-administrator).

One MA/MS institution has made progress on **underrepresented groups**, with a cohort-based model to recruit and retain students in all STEM departments, and training for faculty on improving curriculum and student support specifically for “more diverse” students. These initiatives have been designed and will be implemented in the future. This initiative was successful due to collaboration with other departments (biology) in order to secure a HHMI grant.

Three institutions have instituted some **change to the major**, with a two-phase declaration system, and new certificates in geospatial technologies. There are also plans to provide Engineering Geology programs, an MS in Geophysics, certificate in climate, and major in climatology. **Changes to courses** were made at two institutions, with upper level courses being redesigned to fill curriculum gaps, addition of a Tectonics course, addition of Hydrogeology as a core course, and a new general geology course in Natural Hazards. Close advising by faculty has encouraged students to enroll in elective courses. Enrollment in a general education course was disappointing.

Other progress from these institutions included a revised plan for faculty hires and successfully receiving requested new faculty line. Work with county water department on new groundwater monitoring wells provides new internships, teaching opportunities, data for research, recruitment, outreach to K12. An effort to offer Geologic Hazards and Resources as dual credit with high school was ultimately cancelled by the high school.

Successes and Strategies

Hosted an *NAGT Traveling Workshop* called "Building Stronger Geoscience Departments" where created an action plan for curricular revision and followed through with numerous department meetings dedicated to developing a new curricular model, including sharing it with a student focus group for feedback.

Open communication and complete transparency with all stakeholders. Sharing summaries from the Summits, along with the employer-vetted concept and skills matrix, helped greatly with faculty "buy in."

Spreading the word about the collective community agreement on what undergraduates should learn and be able to do from the Summit initiative to colleagues across the system.

Backwards design was very helpful -- starting by identifying key student skills and knowledge, then defining student learning outcomes and then mapping these to a course matrix. Perhaps the most helpful was the two-day workshop during which we developed the very specific action plan (with faculty names and deadlines attached for each task) for curricular revision.

Made a matrix that is a progression of courses and our previously articulated Knowledge Skills and Dispositions to map progression (not just coverage), then inserted our assessment outcomes into the matrix to inform curricular discussion.

Best strategy is to allow faculty to take ownership of process – slows work, but best way forward.

Personal advising by Geology faculty, coupled with curricular changes increasing the number of compulsory classes at the expense of electives worked best.

Collaborate, and be involved positively with your college. We (Geology) became a model for other departments to use to develop assessment plans university-wide. On accreditation site visit the vice-provost in charge of managing the assessment program and developing the materials for the university's accreditation, cited our models as being critical to the university's successful accreditation review.

As an example of unintended consequences, in an effort to recruit first year students, we collaborated with other chairs in Biology, Chemistry, and Science Education to develop and submit a successful proposal to the Howard Hughes Medical Institute (HHMI). This project presented plans to develop a cohort-based model to recruit and retain diverse students into STEM departments (in this case, Biology, Chemistry, Geology, and Physics) and institute training and mentoring for faculty to improve our curriculum and student mentoring/support for more diverse students.

External facilitators helped work through the initial stages of curricular reform. It was valuable for all to dedicate uninterrupted time to thinking deeply about curricular goals, what is being done, what to do, and to be able to discuss these ideas and concerns freely among the group.

Invited representatives from the State Board (employer of students). They were very receptive to the request and their presentations were highly motivating to faculty and students. An outside authority represents competencies vetted by employers.

Challenges and Roadblocks

Faculty resistance to change – but two new faculty members (out of 6) and their energy and commitment to this process are really helping us move forward.

Personalities has been the biggest one. It has been more important to "win" than to actually develop functional programs.

Faculty took different approaches on course survey for skills and concepts and the reliability of the data is being questioned by faculty as a whole. I wish I would have been more organized in the way we collect this initial data.

Time.

New university mandates, strategic plans and initiatives have taken up all our time.

Limited time available for the few faculty (small department) to execute plans.

Workload for faculty heavy.

Significant decrease in number of faculty. Lost a faculty line due to low enrollments.

Smaller departments are scrambling to stay above water with limited people and resources.

Sidetracked by our campus converting from a quarter to a semester system and creation of a new general education program.

Overcame obstacles because I became Associate Provost at the university.

Associate dean/dean thought BS geology program had too many credits required and was too rigorous – scaled back slightly without giving up on rigor that we think is important if our graduates are to be competitive.

Upper Administration: Main roadblock is our dean who does not work well with departments in the college.

Lack of support from University Administration, which continues to impose its own set of changes on departments without consulting the faculty and is putting pressure on to increase the number of majors in Geology.

<u>Advice</u>

Use the concepts and skills matrix to your advantage, as an instrument that was nationally vetted by geoscience faculty and employers.

Key step for us was bringing in external facilitators (NAGT traveling workshop) to help us work through the initial stages of curricular reform. It was valuable for all of us to dedicate uninterrupted time to thinking deeply about our curricular goals, what we do, what we want to do, and to be able to discuss these ideas and concerns freely among the group.

Planning is everything, but actual implementation takes time. Planning should include personal networking and faculty buy-in internally (departmental level) and externally (Senate level). The departmental plan should link to the university's strategic plan. The plan should be based on data, references, and examples; the plan should include SWOT analyses and link to program review (self-study).

Be persistent, encouraging, and don't expect things to change overnight.

Slow down the pace of changes, as faculty, students, and administrators tend to resist changes/ new ideas.

Take the long view; this process takes significant time.

Congenial working relationships are key.

Collaborate, and be involved positively with your college. NAGT site visit (the Building Strong Geoscience Departments program) helped us develop and implement a good course and curriculum assessment plan. This turned out to be important, as we (Geology) became a model for other departments to use to develop assessment plans university-wide. This positive feedback has been affirming to our faculty, and will prove (I hope) useful in resource decisions in the future.

Invite representatives from your State Board (or other agency that hires students). We found them to be very receptive to our request and their presentations were highly motivating to faculty and students.

The six R2 and four R3/DPU institutions range in faculty size from 4-20.

Four D/PU universities submitted progress reports between 2017 and 2020, and two submitted a 2019 or 2020 update. In the field of **curriculum**, one institution made progress in the use of the competencies and skills matrix, and faculty identified skills/competencies to add to the curriculum. Another revised their Environmental Science curriculum to include classes with more rigor and with a broader range across the Earth Sciences and developed two new required courses for all geoscience majors – a discipline-oriented statistical analysis course and an Earth Science Professional Development Seminar course. Plans were made to add e-portfolios and to review general education program in geology and physical geography. Two institutions addressed **pedagogy.** Geology courses were included in a campus wide initiative to increase student awareness of integrated content across courses. A competency-based approach was implemented. The other initiated discussion of active learning strategies and course content in faculty meetings. Two institutions addressed **2YC-4YC** transfer. Meetings between 4YC and 2YC colleges resulted in the development of a transfer pathway/academic map, and approved by Board of Regents. Articulation agreements were completed with four 2YCs and connections were strengthened. One institution addressed **underrepresented populations**, by discussing presentations for introductory classes on the major and career paths. One developed research cohorts that resulted in an increase in the number of minorities going onto graduate school. Future plans to pursue direct contact with promising students, and 2YC students. One institution implemented **changes to the major**, developing a "career-track" and a "general-track", increasing flexibility for electives and specialization, and numbers of majors (especially transfer from Engineering and Physics) is increasing. One institution has plans for **changing courses**, and hiring a new assistant professor with computational geosciences experience to teach courses in technical data skills. An institution that provided a 2019 update reported progress revising Geography curriculum, and the one that provided a 2020 update reported that they developed an introductory-level course called 'Our Violent Earth' which includes the most exciting elements of geology and meteorology in hopes of getting a broader range of students interested in the geosciences. One started an alumni listserve.

Four R2 universities submitted 2017 progress reports, 2 provided 2019 updates, and 2 additional institutions provided new 2019 progress reports, for a total of 6 institutions reporting. Five of these institutions addressed **curriculum redesign,** identifying gaps using the backwards design matrix and having conversations on learning outcomes. Formal curriculum plans, developing unifying themes and lasting knowledge and skills across degree programs is still a goal. One institution developed new BA degree in Environmental Sustainability. Two institutions addressed **pedagogy**, disseminating literature on best teaching practices, incentivizing merit review process to reward faculty who develop and implement reformed teaching methods and streamlining assessment methods. There are plans to redesign introductory geology lectures to include more engaged learning.

One institution met at the summit with local area **2YC instructors**, revising transfer plans and disseminating them to college recruitment offices. No institutions addressed **underrepresented populations** or **changes to majors**. Two institutions made **changes to courses**, addressing issues of

uneven course content across sections and adding engaged learning laboratories. Additional progress at R2 universities included implementation of differential teaching/research/service so faculty with varying roles can be credited for effort. They created a 5-year strategic plan to prioritize new faculty and staff hires, explored and rejected idea to create School of Earth and Environmental science, and implement a new system of undergraduate advising.

Successes and Strategies

Developing the online matrix of competencies and skills being taught across the curriculum was useful in identifying gaps for the faculty.

After implementing matrix approach, we have a more cohesive curriculum that stresses repeated exposure, expected mastery of key skills necessary for conducting research, reporting research (oral and written), analyzing data and designing research plan.

Focused on streamlining student learning outcomes and methods of assessment. This has resulted mainly in attempts to integrate more critical thinking, writing, presentation skills, and teamwork into existing classes. There has also been a concerted effort to encourage faculty to engage classes with more active/experiential learning exercises.

Strategies that worked well were implementing changes incrementally, and as part of planning that had to be done for external assessment.

Retreat was very successful.

After a retreat, faculty generally agreed on the overall goals, concepts and skills that need to be emphasized throughout the curriculum. We did not need to add courses, but we agreed to make courses more consistently emphasize important concepts and skills as a student progresses.

The NAGT TWP workshop was very much a success – we had a lot of great discussions and ideas about possible course offerings – an outcome of these discussions was the development of the Violent Earth course.

We've had the most success implementing change when a small group, or even just one faculty member, is willing to take the lead (rather than top-down).

Identifying a core group faculty to define goals and implement strategies is important.

Try to overcome entrenched ideas regarding what constitutes a "real" BS degree in geology; traveling workshops may help with this.

Creating a poster-size, color-coded map of faculty course offerings and enrollments going back four years was useful for bringing a new Chair up to speed on curriculum and scheduling. It helped identify inefficiencies and how to shift resources to new curriculum initiatives.

To increase recruitment and retention one department developed two tracks that lead to a degree in Geology. The "Career Track" will prepare students for either graduate school or employment in the field of geosciences. The "General Track" provides the student with a solid background in the geosciences, however it is probably lacking in some of the cognate courses (specifically Calculus, and less rigorous Chemistry and Physics) that a graduate school or geoscience employer may be looking for. This second track was developed for students who enjoy geology but may end up working outside of the geosciences.

In an effort to overcome the limited math and computer skills of undergraduates, we are working to include examples in every course to show how these skills are important and applied in Geological

Sciences. Pairing courses throughout the undergraduate trajectory is effective because students see the connections between courses and can spend more time as teams working on projects.

To aid in career readiness, students in specific geoscience courses are required to complete a 'signature assignment' to be uploaded to an *ePortfolio*. At the end of each semester, student ePortfolio 'signature assignments' are assessed on several specific criteria. A small financial incentive by the University increased faculty willingness to implement the ePortfolio requirement into their courses.

After the State's decision to provide free 2YC tuition to all new high school graduates and adults who have not completed a college degree, we made great strides in developing 2YC to 4YC geology transfer pathway/academic map with area schools.

Challenges and Roadblocks

Convincing certain faculty that they might need to change their courses to include important competencies/skills can be difficult.

Problems with obstruction from senior faculty reluctant to relinquish control that they have historically exercised.

Difficulty to get faculty to make concrete written plans and continually had to show by example how intertwined our curriculum matters are and need to be discussed across department not in discipline specific meetings.

Difficult to get faculty to pay attention or focus on curricular issues, particularly assessment.

We are a small program (4 faculty) and one faculty member is a reluctant change agent.

The new Chair had trouble motivating senior, tenured faculty. By enlisting the help of their undergraduate coordinator, who knows the curriculum in detail, he was able to fill in the blanks and create a matrix.

Progress has been hampered by a lack of faculty buy-in and a shrinking faculty size. Older faculty are traditionalists insisting on status quo creating obstacles to change and untenured faculty are afraid to speak up.

Personnel turnover and a necessary focus on hiring took time.

No internal accommodation or reward for any of these efforts. The Geoscience Program Coordinator position does not come with any course release and so any time spent on program initiatives has to be extracted from time spent on a high teaching load (3 courses per semester) or from the Coordinator's research program.

Progress has been hampered by the overriding crisis of the budget and higher education funding situation: ~70% budget cuts and my undergrad program has seen a 50% decline in majors."

We are just beginning to hit roadblocks (2020 update) because of budget cuts in the past year, loss of staff and other financial uncertainties.

Concerns regarding differential teaching implications on promotion and tenure of junior faculty. Make sure metrics for P/T are well understood.

Limited math and computer skills in our undergraduates, so introducing math and computation is difficult. We are working to include examples in every class to show how math and computational skills are important and applied.

We need to do a better job of communicating to students what our expectations are.

One difficulty we face is collecting data about employment possibilities that we can use to induce administration support and serve to attract potential students and their parents to our program.

The University Marketing office has been uninterested in working with programs.

Plans were slowed by continued governance problems associated with a poorly conceived/planned merger that occurred 12 years ago. Convinced the faculty to re-think our entire charter.

No time or resources to increase participation with 2YC campuses.

Advice

Utilize an undergraduate advisor to let students know what are the overall goals of the obtaining a degree in Geological Sciences. They need to see the big picture. Also, career advising and access to internships are key to opening up students' horizons.

Be patient and be persistent. Although we are making progress we are still at least a year away from having concrete evidence of progress.

I think the best piece of advice is to be patient, but insistent that changes can improve our offerings and be beneficial to our students and to our program. In times of budget problems, these kinds of changes can be program savers.

In my experience, making slow and steady changes incrementally was received best by most faculty.

For major changes in governance, start early with a rational group of faculty to gather opinions. Don't let a few individuals dominate the conversation in a general faculty meeting. Some may take a position that they think is supported, but in reality the junior faculty are afraid to confront those individuals. Set guidelines for behavior in faculty meetings (at least that has become an issue for my faculty).

Take it slow and spend the time to get faculty buy-in. Before you start, figure out how to overcome entrenched ideas regarding what constitutes a "real" BS degree in geology; traveling workshops may help with this. Be prepared to do a lot of background research and bring that to the table before you engage your faculty in discussions involving major changes. Incentivize things that you can as Chair.

Be more realistic about expectations.

Paving the way for regular discussion among faculty is critical to having a functional department. Regular discussions on teaching can dispel preconceptions about what your colleagues may be doing – they can also lead to greater cohesion and integration in the curriculum, along with new course ideas and teaching strategies. As we move toward figuring out how to operate under new challenges (whether that be a financial crisis, a global health crisis, or, both), I think this communication and teamwork will be critical to keeping our department afloat in uncertain times.

If you are at an institution where merit pay increases are possible, you can encourage change by increasing the weight of various faculty activities in your annual merit review process. If you make "uses engaged learning practices" worth 20-30% of someone's teaching evaluation score in your merit review, and if you wield that evaluation sincerely and critically, you will get people to start using engaged learning practices.

A good relationship with the administration is useful: be positive, and serve on committees. But, also be careful and be prepared for unforeseen changes. Remember to emphasize the importance of the liberal arts, if yours is a liberal arts college.

Communicate curricular decisions to the Dean and develop a budget to support implementation. Deans who are not geoscientists may not be understanding of why the faculty is proposing changes, so on-going communication with the Dean about decisions being made is important.

The twenty R1 institutions range in faculty size from 5-51.

Sixteen R1 universities submitted 2017 progress reports. Four of those institutions provided 2019 or 2020 updates, and four additional institutions provided new 2019 progress reports. All but one of the institutions addressed **curriculum redesign,** through a range of approaches. Most of the institutions used the curriculum matrix to describe the current program and design a set of recommendations outlining curriculum reform. Changes include elimination of redundancies in curricula, discussion of revising sequence along lines of core-competency goals, implementation of competency-based BS and BA curricula, implementation of a common two-year core curriculum for three undergraduate degree programs and other revision of degree programs (BS Geology and BS Geophysics.). Strategies for faculty buy-in: modest tweaks, plans for faculty to review for consideration, discussion, amendment as necessary, and approval, eventual implementation. Additional approaches to curriculum design include submission of a NSF pathways grant, plans for future work on assessment plans, and creation of a "learning goals and outcomes" document with concepts, skills and competencies for undergraduate curriculum. Updates in 2019 include a desire among younger faculty to continue moving on curriculum reform.

Six institutions made progress on addressing **pedagogy.** These changes include emphasis on experiential learning, career-building exercises, scaffolding writing throughout the major, and field instruction. Additionally, it included providing professional development information to junior faculty and support of faculty to pursue their interests in course reform while ensuring that peer evaluators are aware of this encouragement and of the possibility of poor student evaluations along the way. Peer mentoring in active-learning classrooms, in which "new" faculty co-teach courses with seasoned instructors and then take over the course as lead instructor after 1-2 semesters, along with new peer teaching evaluation that includes teaching practices inventory.

Two institutions addressed **2YC-4YC transfers,** through meetings with local community colleges and submission of NSF Pathways grant with a primary goal of connections to 2YCs. Three institutions have future plans to address **underrepresented populations**, preparing grants for future submission aimed to increase underrepresented participations in programs, outreach, and pedagogical reform to promote success for underrepresented minorities and women, and development of plans associated with campus-wide initiatives to develop an inclusive excellence plan.

Four institutions made **changes to the majors**, reducing the number of majors and options, creating new programs (BS in Oceanography), merging and aligning 3 degrees into one, and eliminating majors. Four institutions worked to **change courses**, with new courses/curricula first introduced as electives prior to full enrollments during the following year, revising specific courses (separating Field Mapping from Structural Geology), renewing the non-majors core curriculum through addition of interdisciplinary courses, adding "intersession" courses to promote student progress in the degree, and developing online courses/formats for 100-level, non-major courses. Additional comments from the 2019 updates include: addressing skill gaps recognized as a result of matrix-based curriculum redesign, and how to assess whether curriculum changes are leading to better student learning outcomes.

One of the institutions does not have a geoscience program, but proposed and was approved for a new interdisciplinary minor in Environmental and Sustainability Studies that works for six colleges and is working towards making this a major. A wide range of science electives and a mandatory interdisciplinary methods course has contributed to making the minor successful.

Successes and Strategies

We brought Dave Mogk in to present a seminar and afternoon workshop on undergraduate Geosciences curriculum planning and content. Initiated a special curriculum committee to make recommendations on courses, pre-requisites, learning objectives, and alignment.

The SERC pages on retreat planning and Backward Curriculum Design are very helpful for planning a retreat.

Making progress on curriculum reform required an all-day retreat, across campus with catered meals. That bought the eight hours x 40 faculty required to get the basic data, which a smaller group of staff and leadership could then use to create the final matrices for all three undergraduate tracks. After identifying gaps, courses have been redesigned to emphasize the competencies and skills identified in the workshops.

We are now using the matrices to help revision our curriculum. We have long thought we were good at hydrology, but the matrices have identified that a student could get through our curriculum without encountering much hydrology, which is reflected in the poor performance of many students during the Hydrology Section of Field Camp. We are now exploring ways to enhance fluid-related content throughout the curriculum.

We really like the matrices, and they are resulting in action.

Running all of this through a committee using a matrix “straw-man” allowed us to get beyond the minutia of faculty concerns that can grind these efforts to a halt. One-on-one meetings also allowed us to get information quickly and in an environment that wasn’t threatening to the faculty.

Faculty buy-in may be facilitated by progressing slowly enough to allow feedback. For example, for two weeks the department filled two walls with posters listing their learning goals. This allowed everyone an opportunity to provide feedback.

Department chair guided debate, built consensus, and got faculty approval to implement most of the proposed change.

The most successful strategy after getting faculty approval to implement the agreed upon curriculum changes was to delegate the University mandated submission process to a single faculty member and grant her a teaching release. The submission process was a lot of work and it could not have happened without the dedicated attention of one person.

Changes made from previous external review are well established and faculty are now considering how to respond to changing workforce demands by establishing specific tracks within our degree that allow students to tailor their degrees earlier in the areas of Petroleum Geosciences, Environmental Geosciences, and Geology.

One of our aims has been to increase quantitative skills for our graduates. We are trying to do this by introducing more quantitative activities across a range of courses. We are also about to launch our own Quantitative Geosciences course. The course will try to address the problem we have that a lot of geology students feel that are “bad at math”. We aim to teach them the math and statistical skills they need for the job market today.

After the University Courses & Curriculum Committee blocked the proposed addition of a Data Analysis course in our department, the solution was to instead require a similar course taught by a sister department that had already been approved by the University. While the data sets will not be geological the teaching load is shifted from us to another department.

I have made it a regular practice to discuss approaches used in teaching, both at introductory and upper level, with all faculty during annual reviews and mid-year update discussions. When I hear something new and innovative from one faculty member, I share that with the other faculty members as I talk to them so they can consider whether it might work for them. It means they don't have to go out looking for new ideas (saving them time), but it also makes it clear to them that their colleagues might be doing some more innovative and imaginative things in their classes than they are. As a result, more faculty are engaging in active learning approaches.

Time (months, years) and patience. One step at a time worked for us, so it took us MONTHS to get through, but this takes time. You cannot rush this, faculty have to see the results, go away and ponder, then come back.

Having open dialog and getting all stakeholders involved in the process, but we still have a long way to go.

Enlisting a core group of faculty members who could serve as representatives from different parts of the department (bottom-up instead of top-down was key) and taking time to process best practices. The core group should be impassioned by the objectives, but has to be willing to compromise in the end if necessary.

Engage faculty. I am lucky that our faculty, at least a group of them, were relatively willing in participating these activities, once they understand that these activities will strength our department's standing and ultimately benefit the students and fulfill our long-term vision. We did have a retreat and one of the two major agenda items of the retreat was on teaching.

Empower faculty to champion. We now have a very unlikely 'hero' leading the efforts on developing the concept-skill metric and revamping our freshman-level classes. I said "unlikely' because that faculty had always put research above everything else.

We noticed that we had placed much of the transferrable skills in specific classes (e.g., writing, in one course titled Scientific Communication). This meant that students would get these skills once, but maybe not again. We are now alpha-testing infusing these transferrable skills into the majors courses (e.g., writing exercises, taught by a second instructor who specializes in writing, etc.)

Just getting the faculty to separate conceptually the curriculum issues from "I want to tell you how to teach" was a major success. The discussions were good.

We got faculty into the classroom to break down the mystique of "flipped" classrooms. It's not complicated or scary but the buzzwords put people off. Showing them and making them part of it breaks down these preconceived notions quickly!

Peer mentoring in active-learning classrooms has been successful. "New" faculty co-teach these courses with seasoned instructors and then take over the course as lead instructor after 1-2 semesters. Introduction of a new graduate training course with specific training in active learning greatly improved TA support in these types of courses.

Early career faculty are most receptive, in a one-on-one setting, to fairly simple, low-cost approaches that might enhance their classes.

We are slowing drawing more faculty into transformed introductory courses and these experiences appear to "trickle" up to their major courses. The mentoring approach used within the transformed courses were very successful. Student evaluations for these instructors were immediately high without any of the dips seen with other implementation strategies. The TA training course was successful and is going to be expanded this year to include more strategies for student success (time management, etc.).

New set of interdisciplinary courses for 1st and 2nd years using innovative instructional methods such as the flipped classroom and blended learning. Other faculty have seen the effectiveness and have started implementing these in other courses. As part our assessment activities, faculty members discuss the effectiveness of newer teaching methods compared with that of the older teaching methods.

Used university resources. Our Center for Teaching Excellence has an implementation grant in STEM that allows for some support for faculty who transform courses.

Successful participation in SAGE workshop (Supporting and Advancing Geoscience Education) where selected pedagogical methods were summarized and demonstrated.

Changes in leadership and new hires was a catalyst for change for departments.

Working with the deans and trying to get more resources. We successfully gained a new tenure-track FTE on geoscience education through a special opportunity hire. We may also get additional TA support for the new freshman-level courses we are developing. Deans and upper administration were happy with our willingness and efforts; how can they not support?

Social media is an effective tool for reaching students. We have an up-to-date Geoscience Undergrad Facebook page designed to help facilitate the academic and career goals students of majoring in Geology, Geography, and Environmental Science and Policy.

Collaborated with Science Ed to submit a NSF Pathways grant (to connect with local 2YCs).

Working with science colleagues (Biology and Chemistry) mostly worked in establishing the interdisciplinary Minor in Environmental and Sustainability Studies, because we had a mutual interest in getting students enrolled in these classes.

<u>Challenges and Roadblocks</u>

A fundamental split among our faculty on what the future of geosciences should be. Some cannot see that geosciences need to be any different than what geology has been for decades. They want nothing added, nothing removed, nothing changed. They will concede adding something non-traditional (such a courses on climate or water!) as electives, but never at the expense of something they regard as fundamental. Other faculty feel that geosciences is changing and needs to change to meet current and future needs, and are trying to push for a curriculum that better connects geosciences with sustainability.

Senior faculty have been so recalcitrant that some have even opted to phase in their retirement so as not to be bothered with discussions of curriculum and updated pedagogy.

Some faculty are not interested in critically evaluating teaching and curriculum. While they may want to do a good job individually in their courses, there is little interest in thinking holistically about the undergraduate program and how its pieces fit together. There is no mechanism to enforce adoption engagement by faculty. Instead the effort is driven by a small group (~6 out of 23).

There was the expected overenthusiasm for expanding every part of the curriculum as too important to miss. We did projections of how much space was in the degree, how many courses we could reasonably teach, how much lab space we had, in order to inject reality.

Difficult to keep large faculty committee focused and productive.

There was some initial chaos when these ideas were initially vetted in a faculty meeting to the entire faculty.

I developed the competencies matrix to identify areas of strength and weakness within our program. The faculty felt, we were covering the competencies we wanted. However, beyond that, I have not been able to get faculty to engage with this approach and the matrix has largely been ignored since

Convening a committee to establish program-wide learning goals and outcomes went fairly well. But I've realized that we have no mechanism in the department to enforce anything else. There is no way to force putting these learning goals in to any course, and no mechanisms to enforce assessment of these. The biggest problem to achieving our action plan is faculty inaction. This endeavor is largely not a priority for the majority of our faculty.

No matter how good the idea, it always comes down to politics and relationships. Everyone agreed it was a great idea, but everyone said no, not until we spoke with and got the approval of x, y, or z. Meeting-after-meeting, presentation-after-presentation, briefing-after-briefing, we finally got decision-makers to agree that it was not only a great idea, but that we also should go ahead and pursue it.

Have a vision and share that regularly with the faculty, but don't expect miracles.

Early-career faculty feel tremendous pressure to do their research, and so investing too heavily in pedagogical experiments ranks low. However, these are the faculty who are most receptive when I share with them (one-on-one) a fairly simple, low-cost approach that might enhance their classes.

The strongest impediment is senior faculty thinking that this process will tell them how to teach their material. "How to Teach" is a different issue than "What to Teach."

Long-term individual faculty ownership of particular course that may be modified by this process.

No interest from faculty in addressing when teaching methods successes and failures discussed at faculty meetings.

I also tried to establish working groups around several of our introductory-level courses as a way of sharing best practices, but those faculty who would probably have benefited most by participating were least interested and complained that they did not want to be told what they could and could not teach. Getting well-established faculty to change their approach can be extremely difficult. They want to keep doing what they've always done.

A challenge that we think the geoscience community will be facing: a mismatch between our hopes and dreams vs. the reality of how difficult it is for students to transition from just absorbing knowledge to actively engaging in the process of generating new knowledge.

Getting faculty to teach in areas that may be higher enrollment.

University Committee questions our proposed course in Data Analysis. Solution was to require a course in another department.

One of the biggest roadblocks we have as a department is inadequate facilities and resources to fix them.

Time (2 departments).

Merger of programs: Unit head and faculty recalcitrance, not because the idea isn't good, but because of a perception of loss of control and loss of resources like TA-ships, which would be shared by merged program. Our program is a traditional one with easily identifiable core-competencies and the degree we wanted to merge with is elective heavy and the faculty in charge were not willing to list and rank the core competencies they address now, and how those might be modified in the future. Roadblock is working out the administration of this first and second year common curriculum and the buy-in from the three departments (because of the perceived loss of program control over curriculum).

Advice

I've found the SERC pages on retreat planning and Backward Curriculum Design very helpful as I plan our upcoming retreat.

The all-day retreat was REALLY worthwhile. We spent some time explaining the matrix approach, and getting us all on the same page with regards to the Likert scaling. Then we broke into groups, which were fluid so people could join-and-leave multiple groups and real-time feedback could help us all get/stay on the same page.

Aim high but expect setbacks. Be patient. One step at a time.

Show faculty the results of the survey from the Summits and Geoscience Employers workshop.

Let everyone (faculty, staff, admin) feel like they are part of the entire process from the first steps of the initial planning efforts. It takes longer in the beginning, but having everyone on board from the start is worth the (sizable) initial investment to (hopefully) avoid issues down the road.

Don't discuss, plan, or dictate anything without frequently asking for every faculty member's feedback.

Get a core group of faculty that can serve as representatives to various parts of the department; take your time to think it all through and do it right; consider logistics right from the outset. The core group needs passion for the project, but has to be willing to compromise in the end if necessary for agreement.

Try to avoid having the process drawn out; it runs the danger of losing momentum. Incorporate reports to the general faculty on in-progress committee deliberations as a part of the general approach, to keep them apprised, engaged, and able to give committee members feedback (though this would require dedicating a lot of faculty meeting time to the topic).

Patience, patience, patience, one step at a time. All faculty think this was very good for the Department. They might not have "enjoyed" the process, but they realize we made good changes and used the process to motivate the changes. We did NOT look for "overlap". I think discussion of "overlap" would be a "hot button" issue. In addition, some faculty are now passing syllabi a back and forth between prerequisites and courses.

Make sure that there is some mechanisms in place for driving and enforcing your proposed changes.

Slow process. Have committee of earlier-career faculty from diverse fields to build plan. We did start with learning outcomes, knowledge and skills, and these did help the process. Altogether took four+

years. Could have been faster if no other distractions, but three years would have been the fastest from start to finish

Connecting personally and individually with professors built support and created momentum to continue the process. Get faculty into the classroom to break down the mystique of "flipped" classrooms.

As student research experiences are added to the curriculum, the intent is that students are learning what it means to be a scientist. Be cautious of a mismatch between the intent of the research experience and the reality of how difficult it is for students to transition from absorbing knowledge to actively engaging in the process of generating new knowledge.

Check out university/college resources as many have teaching centers or other resources that help faculty learn new teaching methods.

Don't downplay or discount administration or curricular demands at faculty meetings, this is the boat we are in, we must sail it together.

Rubric for Quantifying Progress made toward Action Plan objectives:

The following was applied to quantify the progress a department has made toward accomplishing their individual Action Plan objectives:

- 10-20 – participant shared their plan with colleagues but failed to get faculty onboard
- 20-30 – participant/department did one or more of the following: initiated analysis of existing curriculum; began to produce matrices; provided resources for improving pedagogy; identified specific steps for implementation of plan objectives
- 30-40 – completed department-specific matrices or other plan elements but no tangible outcomes; progress stalled due to external factors (no support of leadership, budget constraints, hiring freeze, etc.)
- 40-50 – plan for implementation defined and initiated (possibly awaiting University approval)
- 50-60 – tangible progress in either curriculum redesign (successfully implemented in a course or two), pedagogy (faculty slowly adopting new ideas, attending workshops, transforming courses) or other major plan elements
- 60-100 – reflects the scale to which new curriculum, courses, pedagogy and other objectives are being adopted in the department

If the primary objective was curriculum and/or pedagogy, but the department made significant progress addressing an increase in underrepresented groups, K-12 teaching, 2YC-4YC, change in majors or additional courses, they increased by 10-20.