Group 1

Q1: Curriculum

-
- Early and regular advising to include prerequisites, career opportunities, internships
- Clear articulation of the learning outcomes of mini-research projects, REU, interns.
- Clear outline of skills and knowledge for MSc, PhD components
- Accept some proportion of black box topics – attracts and retains students
- Collaborations:
  - Consortia of smaller universities; collaborative classes to expand opportunities
  - Industry (dialogue re skills; training)
  - Involve industry in training, classes, use of modules
  - Online coding classes
  - Math classes taught in home departments

Q2: Impacts on students and feeding the pipeline?

-
- Internships with clearly articulated learning outcomes
- Need advising and organizational (like AGU/professional societies) support to link high school to grad school internship opportunities.
- Coordinate activities of facilities (SAGE/GAGE/CIG/OpenTopo) to have boots on ground recruiting at minority-serving institutions.

Group 2

- BREAKOUT GROUP #2 - Take away (BOTH questions were dealt with together)
- We need to consider programmatic-level goals and then see what that suggests for the courses themselves and where students can gain different skills/knowledge – thinking towards both undergrad and grad programs
  - This is hard and requires a lot of collaborative visioning by departments
  - Potentially bring math/data/computer sci skills into department courses to teach more effectively to geosci/geophy applications (and hopefully streamline); also integrate throughout many "content" courses, not just "math for geoscience course"
- Invest in co-curricular opportunities/resources
  - Ex. Something like the Math You Need program could be leveraged for learning mini-modules on a particular skill that support the core course content (upper level math, computer sci, etc.)
  - Educational "infrastructure" like this means everyone does not have to reinvent this stuff themselves
- Intersperse skill/content development with real applications in science/geophysics (paid internships, service learning, problem-oriented class projects)
- These steps require continued professional development for faculty AND continued collaborative visioning of how to make it happen
- Need to make these changes without lengthening the degree time

Group 3: Fundamental Quantitative skills needed

Long wish list:

- Problem solving/analytic skills
- DE, PDE, statistics, linear algebra, programming, data processing/data science, inverse theory, time series
- Practical aspects: instrumentation, hardware connection, data collection

This list is too long- there is no room in existing programs if these were all separate courses

- We suggest that some of this knowledge can be incorporated into existing major courses, for example through practical assignments

Group 3: Curriculum

- Changes have to be made starting at the undergraduate level
- Data science, quantitative reasoning, programming exercises, etc. could be woven into *all* existing earth science courses; in projects, labs, and lectures

Group 3: Impacts on mix & support of students

- We need to avoid larger failure rates and less diversity
- We need to support more diverse students into success:

  -invest in students that arrive with less quantitative preparation

  -bridge courses?

  -teach/repeat quantitative skills in courses with better faculty/student ratios
- Maybe not one set fits all- programs that can be tailored (for example, data analyses skills separate from other skills)

Group 4: What needs to change in current curricula?

We focused on **higher-education** to remain tractable, however:

- Geosciences should be the capstone at high-school
- Students used to get more experience in high-school. Most haven't even opened a spreadsheet

---

- **Statistics** should be taught, with more modern methodologies, using geodata (maybe with the ugly data too)
- **Geodesy** should be better learned within the US earth sciences
  - Europe has dedicated programs, but some are shrinking
  - Some geodetic methods are extremely detailed and w/limited pipeline (other geophysical fields too)
  - US is missing fundamental training, particularly gravity. Ohio state only program with EU style geodesy, ultimately splintered.
  - GETSI is a set of tools/modules for teaching geodetic tools at the undergrad level
- **Programming** (could be general and likely python—for now) Specific toolboxes may allow for shallow learning of black-boxes
- Should have **core geoscience training, with tracks** of specific knowledge.
  - **What should we lose?** Field?, Chem?, Min/Pet?, Historical Geo?, Sedimentology?
  - **What geo do we need to keep?** Structure?, Geomorph?
- **Paid internships** would be immensely helpful in learning real-world application

- Need **more mentoring** (may best be with UG research group) at the undergraduate level.
  - Get research projects and computational coursework in earlier
- Do more work along specific tracks/minors
  - Could be more fruitful for outsiders to get a degree
  - An option may be to allow for **double-majors**

Group 4: What are the impacts of Curricular changes on the mix and support of students

- What happens when we add topics (absorbing more and more knowledge more quickly)?
  - Are we learning **a bunch of black boxes**?
  - Maybe **move BS to 5 and MS to 3 yrs**. How do we do this and not lose underrepresented groups? Not clear.
- Why are geosciences less attractive to underrepresented groups?
  - Playing in the mud is not attractive to 1st generation students
  - Computational learning really goes against this. May be beneficial to attract more UGs: *Not rocks for jocks after all.*
- We need to learn how to attract students *earlier*.
  - Get them excited about making **the world a better place**
  - Make the curriculum immediately **tractable** with applied problems, career/alumni visits
  - **Working directly** with data, collecting new data, looking at operational systems
  - **Attract them early** (most come in as junior/seniors)
    - Physics/Math UGs move more quickly in grad programs. may focus on them.
    - Advertise summer research projects in math and physics
- How do we make UG research affordable (not cutting into other responsibilities)?
  - Research for credit
- Gamification of Geosciences
  - Develop scenarios for specific problems (e.g. with policy)
- Citizen science!

Group 5: What needs to change in the current curricula?

- Teaching of quantitative skills needs to increase at undergrad level
  - Create quantitative tracks, with fewer classic geology requirements
  - Teach the quantitative skills within geo departments – more efficient
  - Need integrated approach that keeps using skills throughout program
  - Challenge is to create courses – easier to do if shared resources exist, faculty can teach a course if don't have to create it
  - Need to promote quantitative skills at high school level, but still need intro undergrad courses, maybe a higher level than currently
- Graduate training needs to become more flexible, not just MS and PhD programs
  - Specialized certificate programs
  - Maybe have several universities teach it together
  - Or have non-university organizations coordinate/facilitate effort
  - Accreditation is a key issue

Group 5: Impacts on the mix and support of students

- Increased quantitative skills can mean fewer students
  - Some students are drawn to quantitative challenges
  - Need to be clear about requirements
  - University admin could be brought on board if can show that more jobs are available with quantitative skills
- Certificates would give more flexibility to students
  - Enter the workforce sooner
  - Employers may accept students with fewer incoming skills if path exists for them to get focused training
  - E-portfolios can show demonstratable skills in smaller chunks than degrees and standard courses