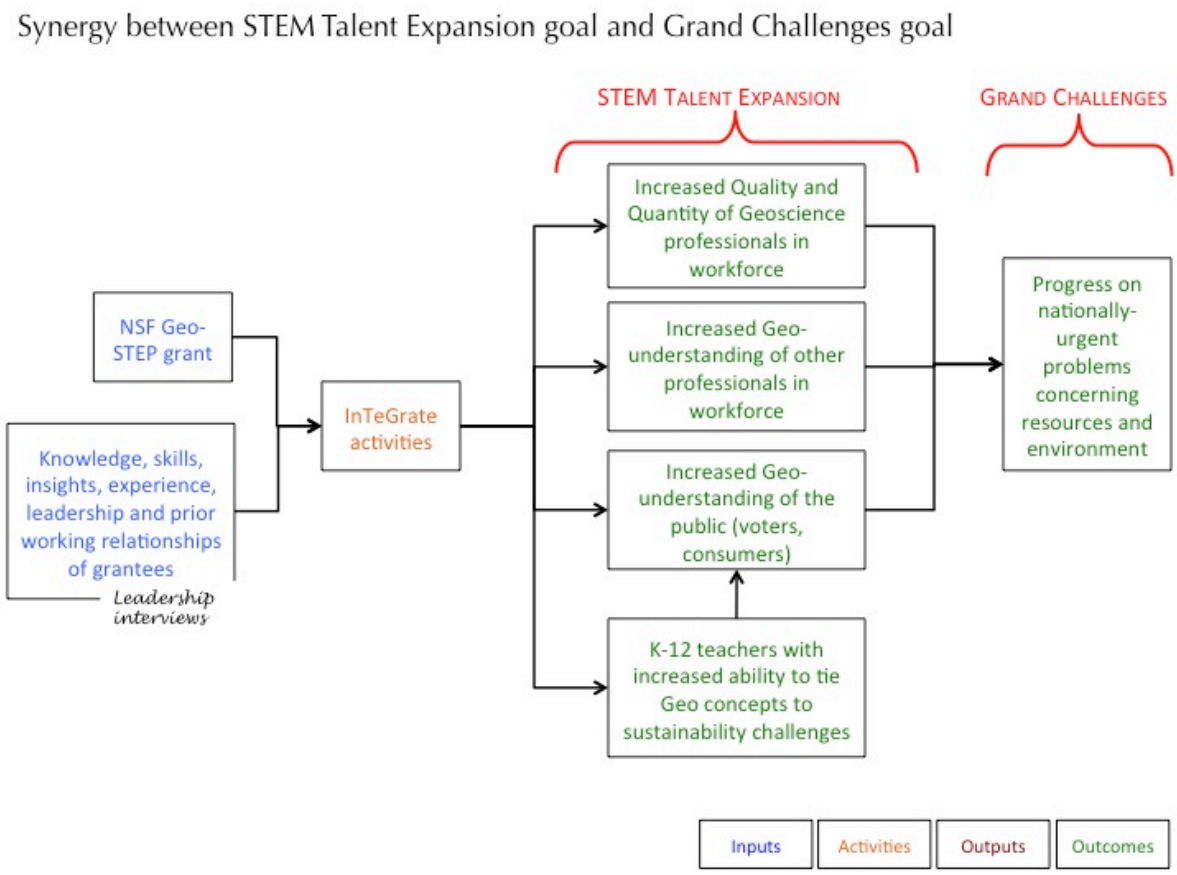

Figure A-1: *NSF's STEM Talent Expansion Program asks each STEP Center to accomplish two things simultaneously: expand the talent flowing into the STEM education and career pipeline and make progress on tackling a major challenge facing the nation. In InTeGrate's theory of change, these two goal are intertwined, as shown in this figure. To make progress on the grand challenges of limited natural resources and environmental sustainability, InTeGrate seeks to increase the quality and quantity of geoscience professionals entering the STEM pipeline. This is considered necessary but not sufficient to tackle the identified grand challenges, so InTeGrate also seeks to increase the geo-understanding of other professions in the workforce, the geoliteracy of the general public, and the capacity of K-12 teachers to tie Geo concepts to sustainability challenges.*

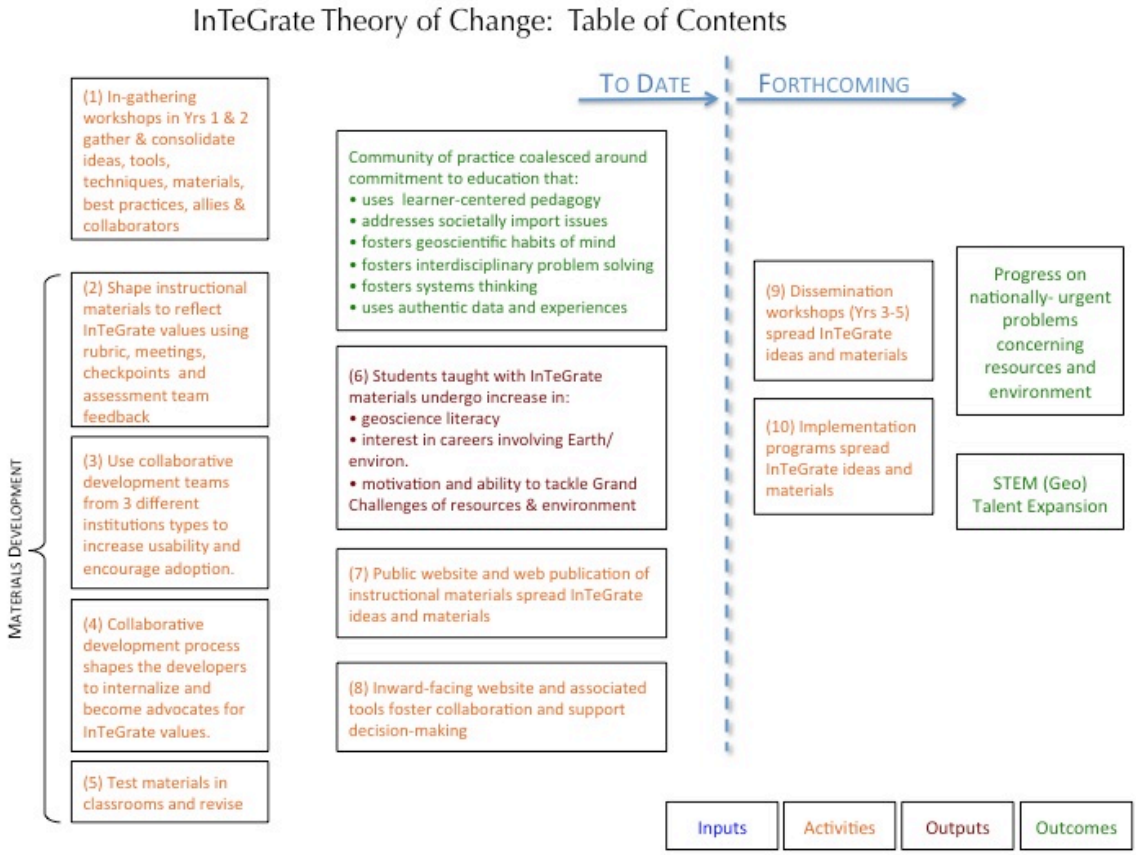

Figure A-2: *Each box on this page is expanded into a flowchart on a subsequent page. InTeGrate Program Element #1, Materials Development, has had the lion's share of effort in the first three years of the project, and so the logic model for that aspect of the project is best developed.*

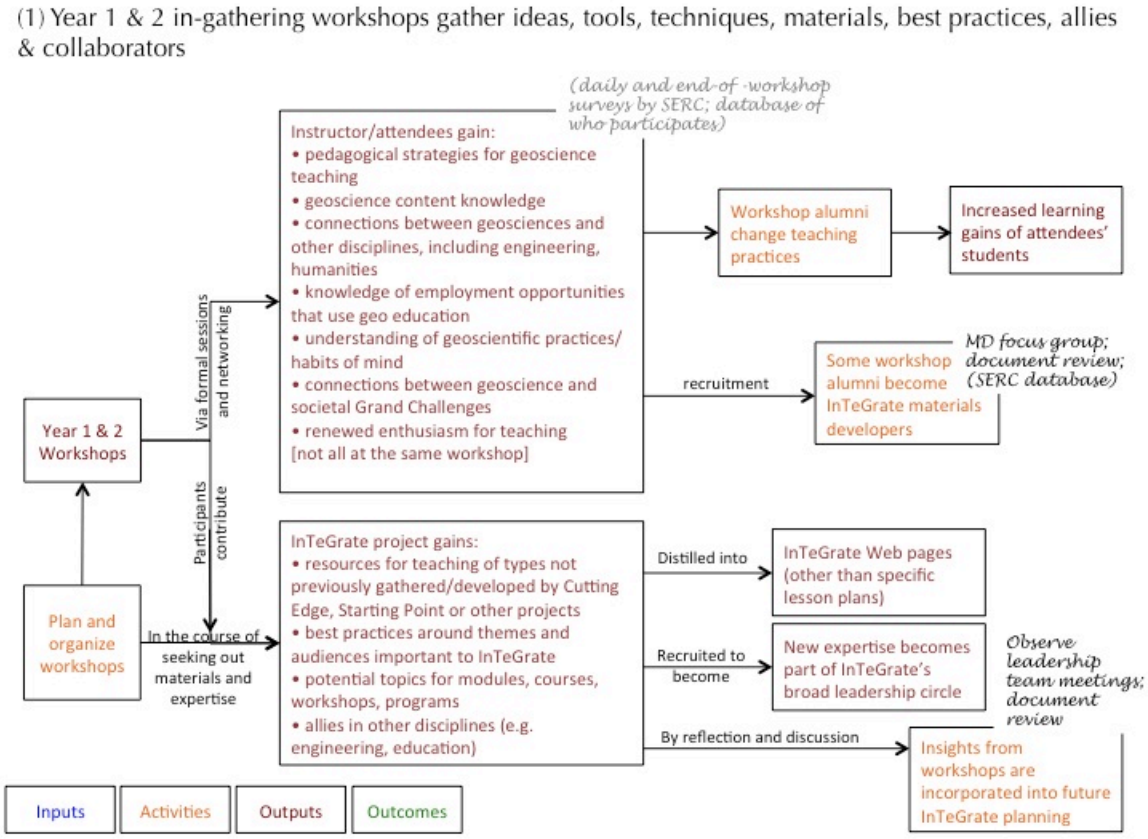

Figure A-3: *Because the leadership team views InTeGrate as a complex system, they tend not to plan for linear cause-effect chains in which one activity results in one outcome. Here we see an example of how one type of activity (in-gathering workshops) is expected to yield two families of outputs: benefits to the attendees, who will leave as better-equipped instructors, and benefits to the project, which will gain resources, ideas, and allies.*

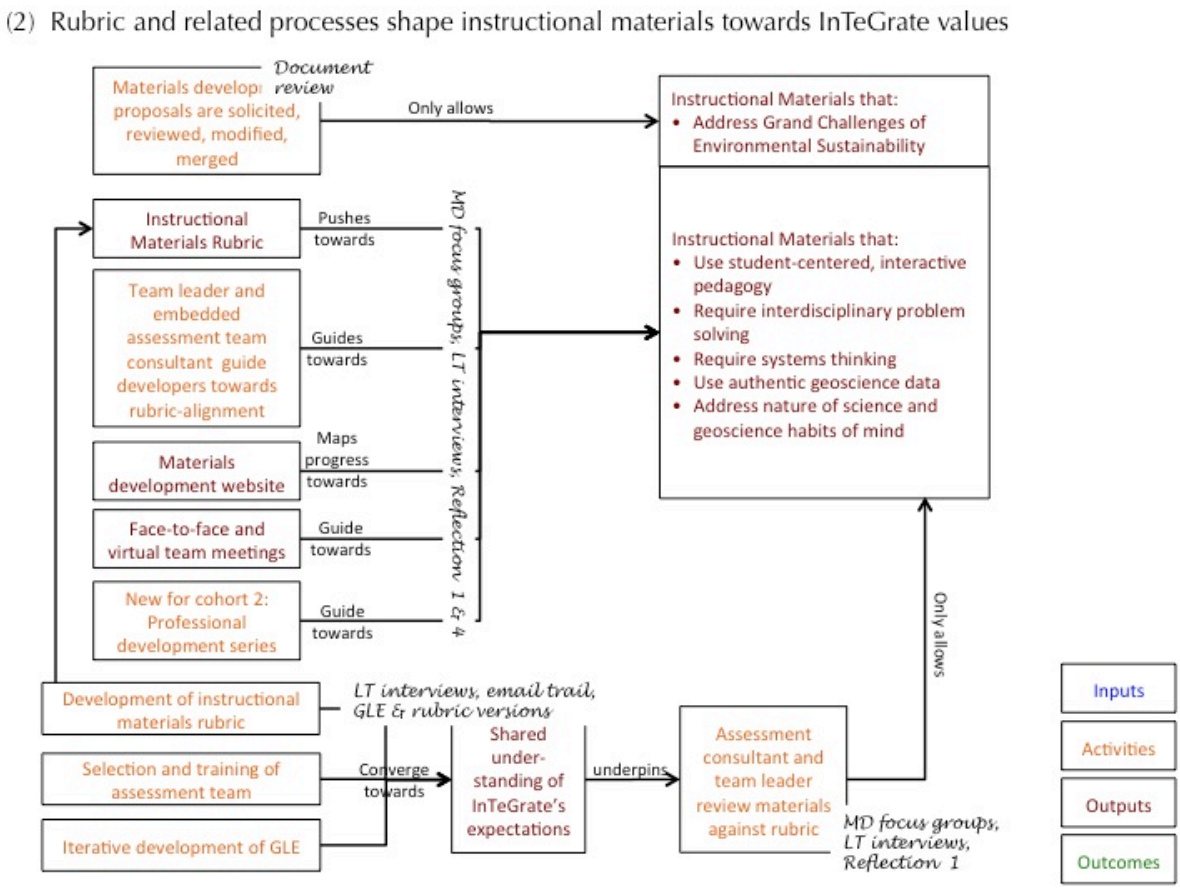

Figure A-4: *In the previous panel, we saw how InTeGrate's complex system has a single activity leading to multiple outputs. In this panel, we see that the converse is also true: multiple activities acting simultaneously are required to nudge the system towards a single desired output. In this case, multiple activities and entities (rubric, website) combine to nudge the materials development process in such a way as to end up with instructional materials that align with InTeGrate's pedagogical guiding principles. There is no effort to disambiguate the individual impact of each of these activities and entities; the output is viewed as a result of the cluster of influencers, acting synergistically.*

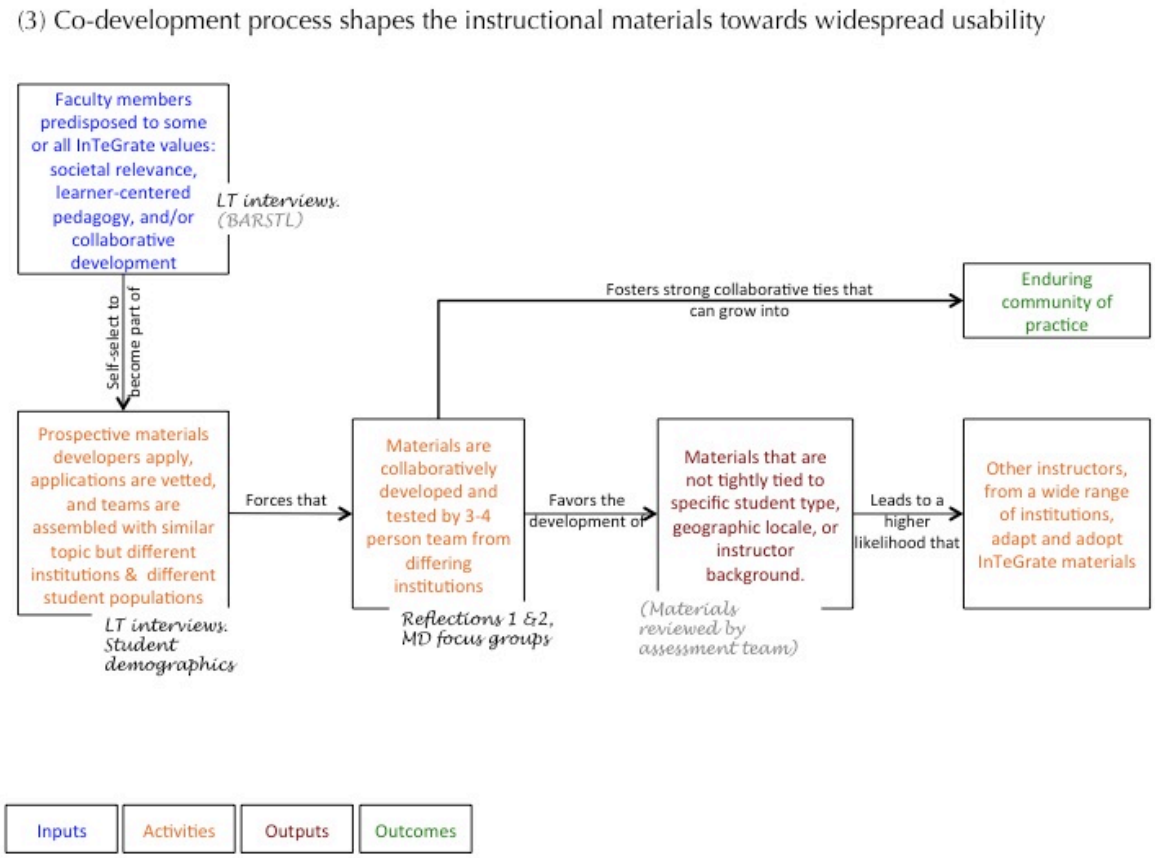

Figure A-5: *In this panel, we see the first green-colored "Outcome." As practitioners of an historical science, geoscientists are accustomed thinking about how events in the world leave traces, traces that can endure long after the causal forces are over. An "Enduring community of practice" is conjectured to be one of the beneficial traces that the InTeGrate event may leave behind. Even after the STEP Center funding sunsets, the community of practice built by InTeGrate could continue to catalyze new collaborations and new initiatives that continue to nudge America's higher education system towards InTeGrate's goals.*

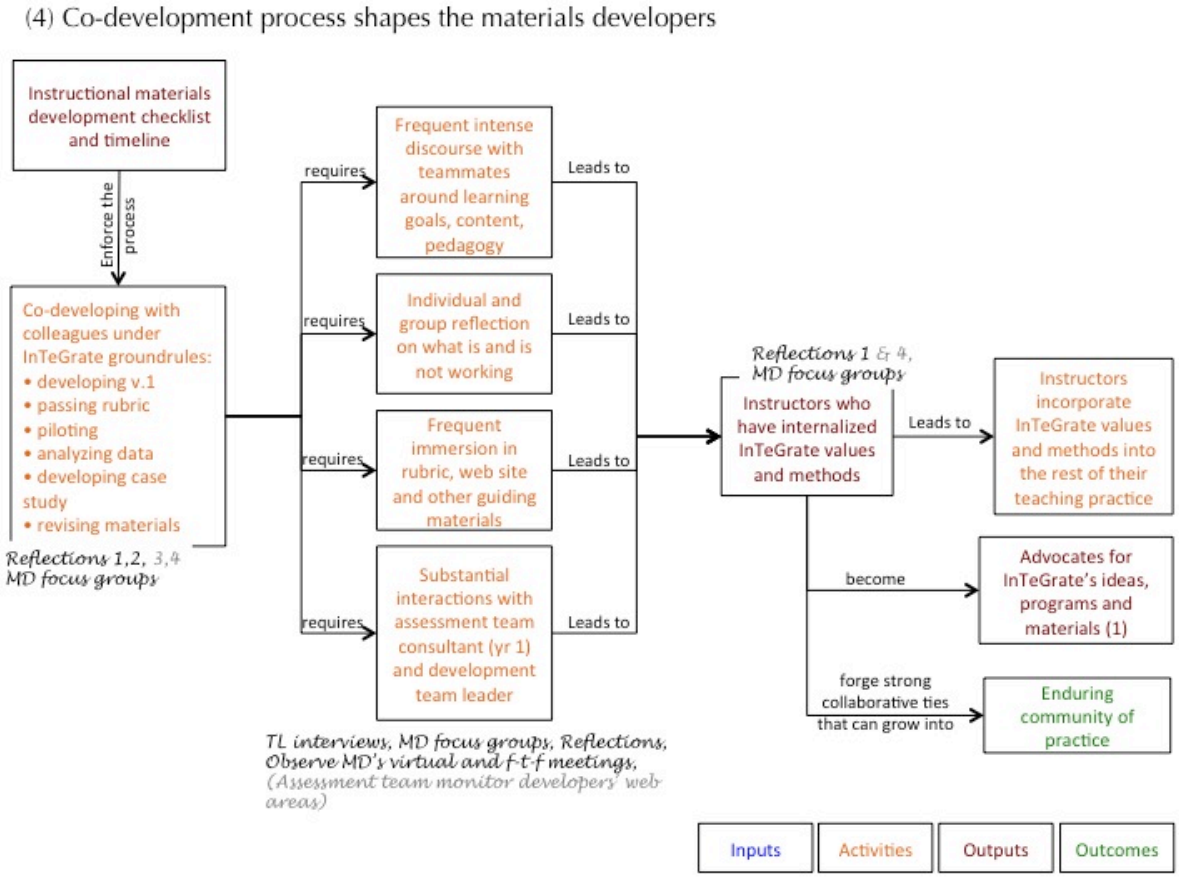

Figure A-6: *On the surface, InTeGrate's elaborate materials development process appears to be designed to shape the instructional materials into alignment with the pedagogical values embodied in the Instructional Materials Rubric. That set of influences, depicted in logic model panel (3) [figure A-5] is true, but it's not the whole story. This panel shows that the same set of processes is also supposed to be shaping the materials developers themselves, into instructors who have internalized InTeGrate's values. This could turn out to be a more profound and longer lasting impact. Long after InTeGrate's instructional materials have become infested by broken links and obsolete factoids, the instructors impacted by their involvement in InTeGrate may still be incorporating InTeGrate's values into the their teaching and advocating InTeGrate's values among their professional circles.*

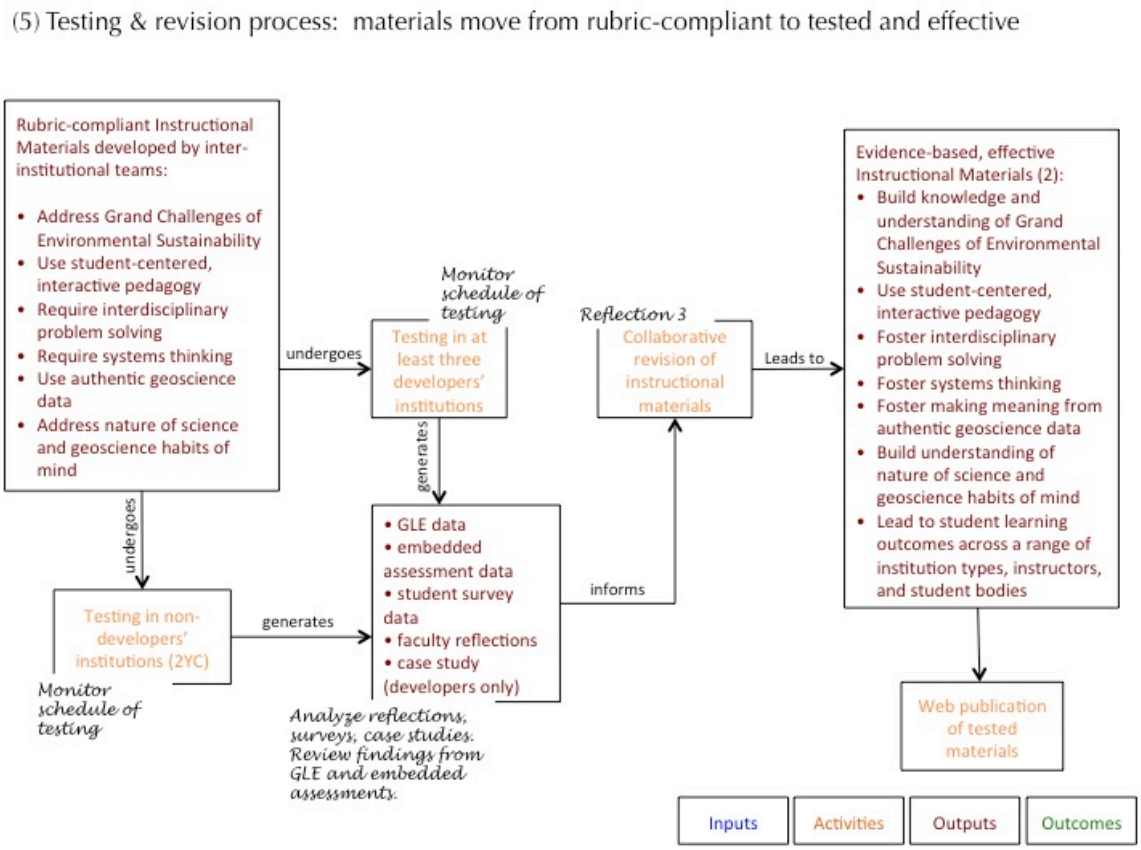

Figure A-7: *In InTeGrate, evaluation is not only the responsibility of the external evaluation team. Opportunities for evaluation, reflection, peer-review, assessment, quality control, and data-informed revision permeate the system. This panel depicts the process of testing and collaborative revision that lies between rubric-compliant instructional materials and materials that have been shown to be useable and effective in classrooms.*

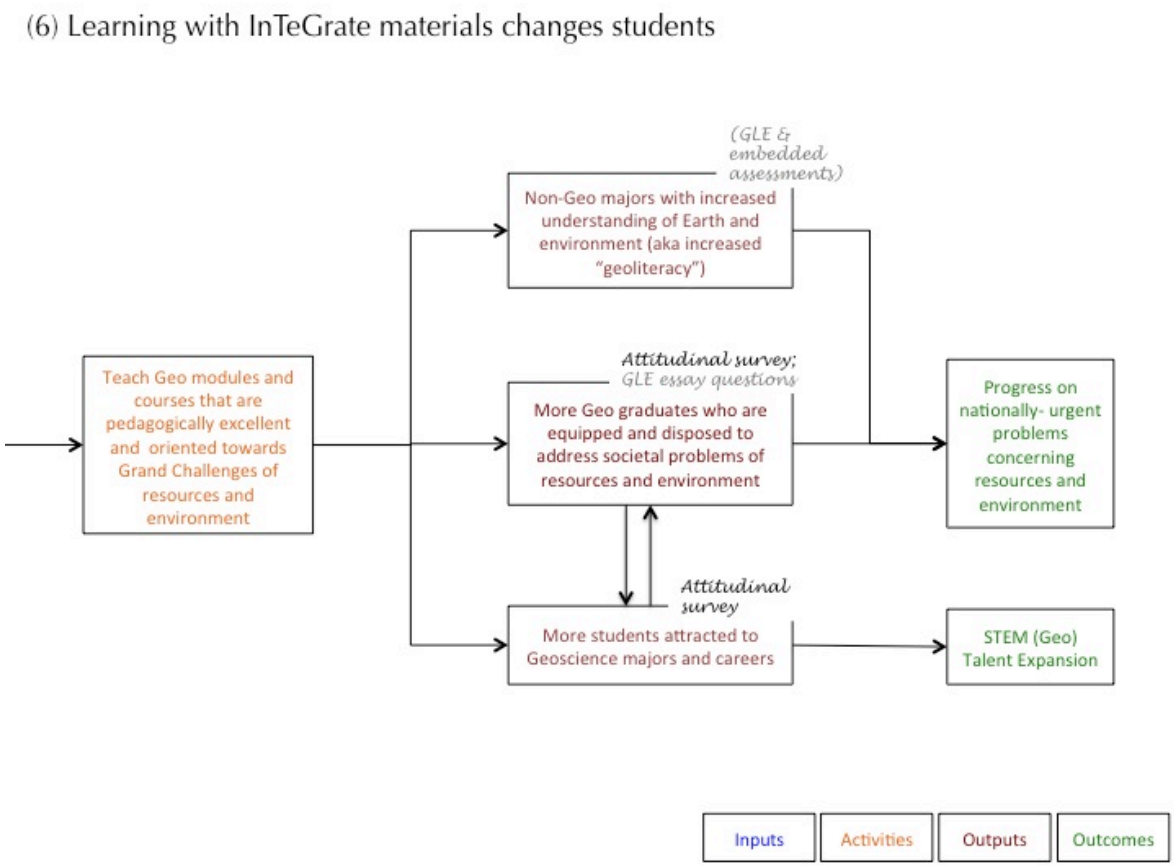

Figure A-8: *Here we see laid out most starkly the set of giant conjectures that lie at the center of InTeGrate's theory of action: If InTeGrate manages to offer modules and courses that are pedagogically excellent and are oriented towards societally relevant Grand Challenges, then hearts and minds will be won, and students will be better equipped and more disposed to seek out Geoscience major and careers and to address societal problems of resources and environment, and they will change their choices and behaviors in such ways that the world will make progress on some of its most pressing and intractable problems. InTeGrate now has a set of instruments in place [the Geoscience Literacy Exam (GLE), embedded assessments, essay questions about systems thinking and interdisciplinary problem solving, and the InTeGrate Attitudinal Instrument (IAI)] to detect whether these changes to heart and mind are happening.*

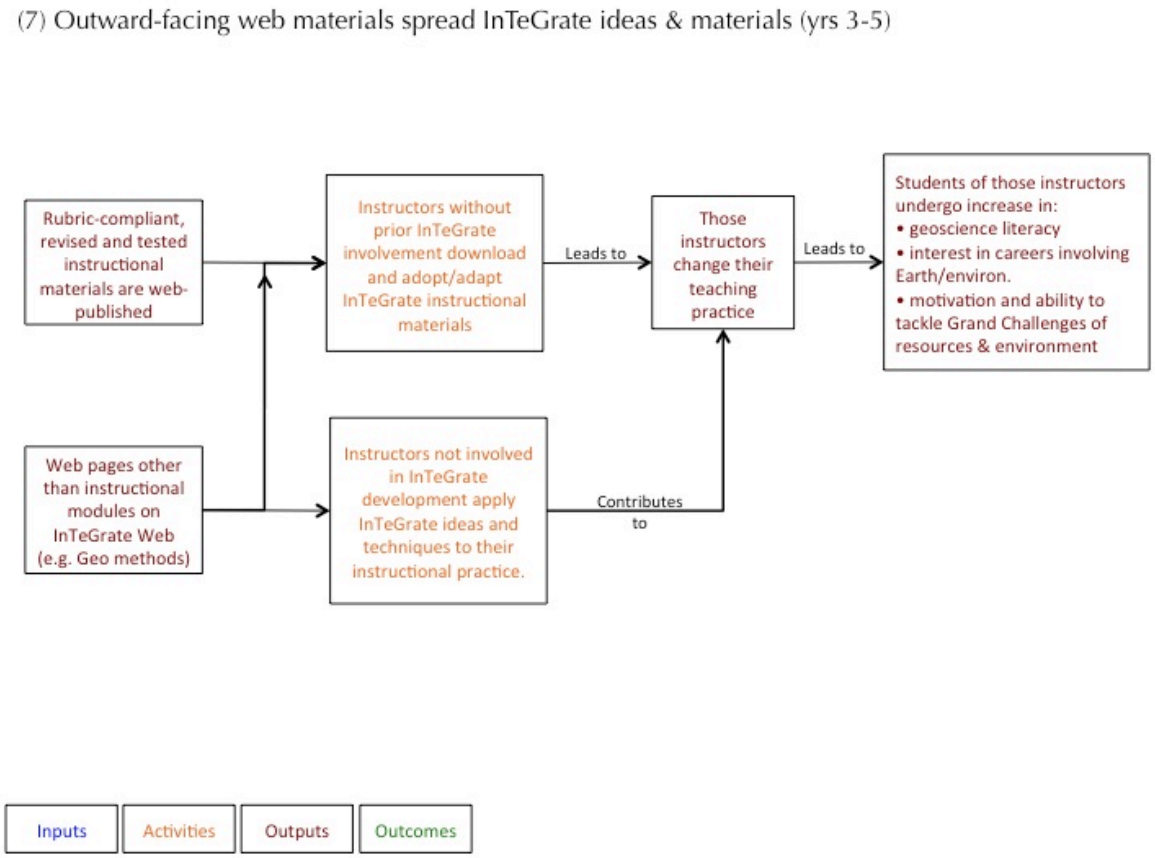

Figure A-9: *This panel of the logic model is mostly conjecture, as the first of InTeGrate's instructional materials were made available on InTeGrate's public website only a few weeks ago. It is an evaluation challenge for the remainder of the project to know how to evaluate whether instructors do indeed "change their teaching practice" or whether students do indeed "undergo increase[s] in geoscience literacy" etc, when the only contact with InTeGrate has been via the website.*

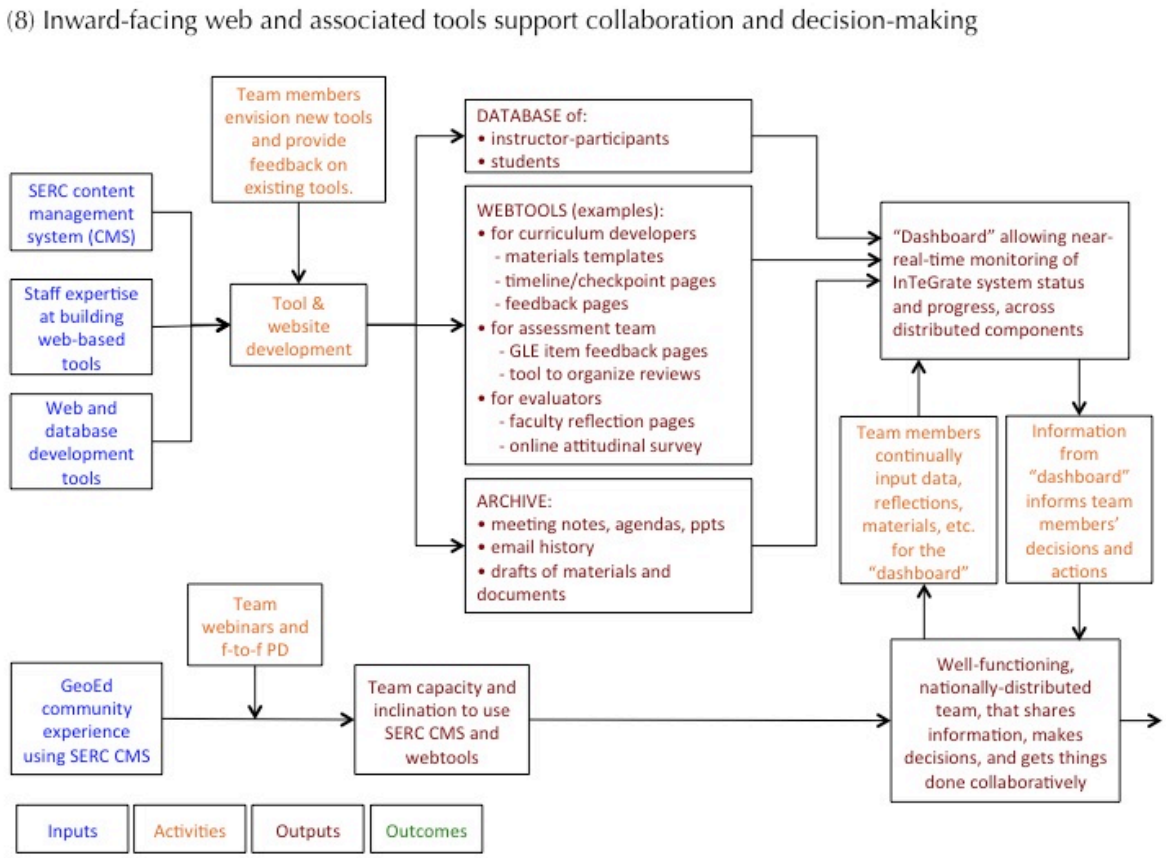

Figure A-10: *Educational reform efforts that consider education as a complex system cannot pre-plan every detail of their intervention in advance. Instead, they need to be continually "sensing" the status of the system and its environment and deploying "emergent strategies" that evolve to build upon what has been learned, respond to challenges, and take advantage of opportunities.88 This panel outlines how InTeGrate is using web-based technology to create a "dashboard" that supports the process of continuously monitoring the InTeGrate system.*

[88] Kania, J., Kramer, M., & Russell, P. (2014). Strategic philanthropy for a complex world. *Stanford Social Innovations Review, 12*(3).

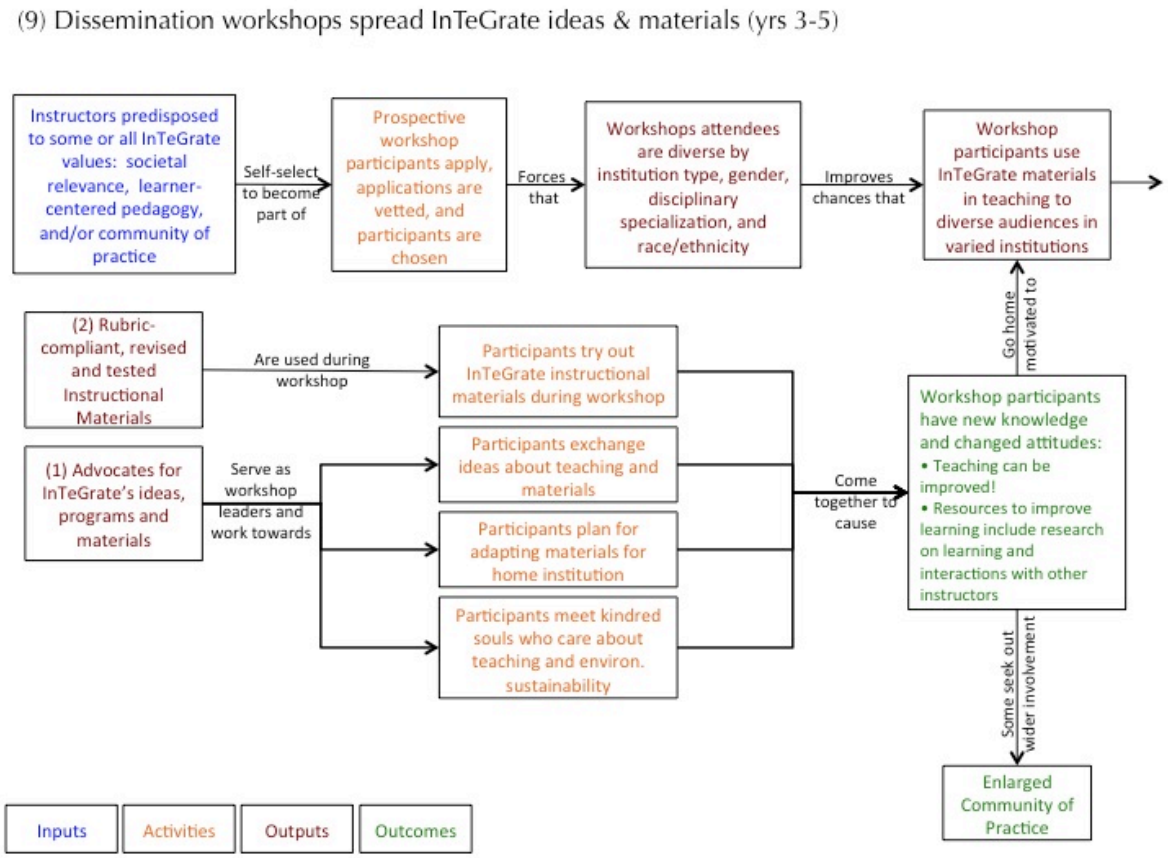

Figure A-11: *This is another panel that is mostly conjecture, as dissemination workshops had to wait until materials were published. The first such workshop happen in October 2014, at the Geological Society of America meeting. These conjectures are more firmly grounded than some others in InTeGrate's theory of action, as they are based on long experience with Cutting Edge and Starting Point professional development workshops.89*

[89] On the Cutting Edge: Strong Undergraduate Geoscience Teaching website [open access]: http://serc.carleton.edu/NAGTWorkshops/index.html; Starting Point: Teaching Entry Level Geoscience website [open access]: http://serc.carleton.edu/introgeo/index.html

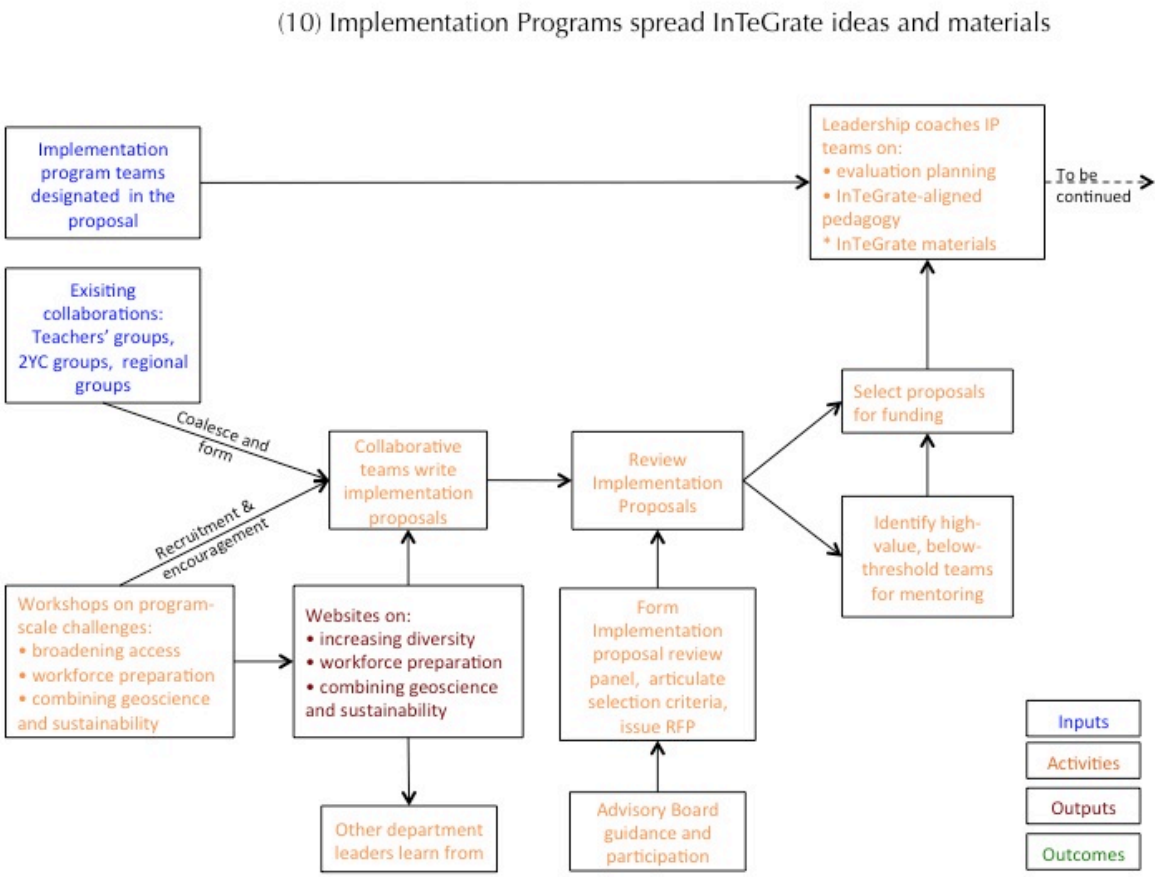

Figure A-12: *Initial activities in the development of Implementation Programs have happened, and are mapped here by solid arrows. This logic model panel will need to be fleshed out as the programs mature. The arrow from "Review Implementation Proposals" to "Identify high-value, below threshold proposals for mentoring" represents a pathway that was not anticipated. When the proposals were reviewed, two were identified as tackling a very important problem but below the threshold for funding. Rather than reject these outright, the leadership team created an alternative pathway to bring these teams into the system via a high-level mentoring process.*