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Case Study: Integrating Scenario Planning into Sustainability Practicums

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Abstract: Sustainability education can productively focus on concepts and/or skills, each playing an important role in preparing students to promote sustainability in society. We describe here the skills-based curriculum in an environmental sustainability practicum designed for undergraduate students. Although our curriculum provides training in numerous relevant skills, we focus here on one in particular: scenario planning. Originally developed in the 1970s by Shell Oil to develop robust business strategies in the face of future uncertainties, scenario planning is applicable to any planning domain where future conditions may be driven by the outcome of critical unknowns. For example, planning for effective community resilience in the face of climate change may depend on the degree of government support for renewable energy systems. In this practicum, students work in teams of 3-4 on the same challenge: *Assess a specified human-natural system for its vulnerability to climate change in the next 20 years and develop solutions that effectively increase the resilience of the system in the face of uncertainty.*

Scenario planning involves six steps: (1) Identify driving forces for future changes; (2 and 3) Identify certainties and uncertainties for future conditions; (4) Rank uncertainties by the degree to which they might affect future conditions; (5) Create a 2x2 grid of possible future scenarios based on the two most influential uncertainties; and (6) Describe the future world in each of these four scenarios. Using creative ideation techniques developed by IDEO for their Human-Centered Design methodology, students then use these four scenarios as the basis for envisioning effective strategies for promoting resilience regardless of how the critical uncertainties unfold (adaptive planning) or for influencing uncertainties to increase the probability that preferred scenarios manifest.

Keywords: climate change, futures, practicum, resilience, scenario planning, sustainability, uncertainties

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Introduction: Course Context

Since its introduction into the public sphere of global environmental policy (Brundtland, 1987), the concept of sustainability has inarguably grown to become one of the most important organizing principles in environmental education. Its broad scope – encompassing natural limits and social norms from local to global scales – offers opportunities to encourage critical thinking by students on a near-limitless range of subjects, ranging from ecological carrying capacities to environmental justice. This has led to a profusion of course offerings in higher education across numerous subject areas that explicitly address questions of limits and time (Sherman, 2008). At our own institution, for example, we have for several years led a summer curriculum-development workshop on sustainability that has included faculty from 22 different departments and programs (Byrne et al., 2013), including those in the languages, arts, and both natural and social sciences.

A rough dichotomy has evolved in how sustainability is addressed in the classroom: concepts vs. skills. Conceptual engagement with sustainability can approach the subject from any one of numerous directions, including (but not limited to) history, critiques, case studies, and application to appreciating the social relevance of the natural sciences. (See Peterson Boring and Forbes, 2013 for a more complete survey.)

Alternatively, skills-based curricula focus on engaging students with tools that empower them to design or assess sustainability solutions. We do not imply here any hierarchy in value or importance of concepts or skills as learning goals; we merely point out that these are two different pathways toward sustainability education. Clearly, each of these pathways has value and each can focus on different geographic scales. In fact, we consider both pathways to be critical parts of a robust environmental education curriculum. It is not enough for educators to provide students with facts and figures, even if this is presented within a critical-thinking framework; students need also to be provided with training to use the tools necessary to do something positive *with* those facts and figures.

In this case study, we first describe in brief the structure of the Sustainability Practicum we taught for four years as part of the Middlebury School of the Environment (MSoE). However, we focus the majority of our discussion on one specific aspect of this structure – the use of scenario planning as a creative tool to aid in the design of strategies to increase resilience and sustainability.

The MSoE is a six-week summer institute, open to college undergraduates from any college or university. The Sustainability Practicum is a core part of the advanced track of study; students in this track must already have had some undergraduate coursework in environmental studies, although given the diverse nature of course offerings across institutions, the specific pre-requisites are assessed on a student-by-student basis. The Sustainability Practicum has two key components:

- Training in the use of skills associated with design thinking and collaboration. These skills include systems mapping, creative ideation, teaming (especially with respect to cooperative communication and group writing), and scenario planning.
- Using these skills *en suite* in teams of three or four to address a challenge posed to them, leading to the development of an implementable recommendation to improve the sustainability of a defined system.

Each team is given the same challenge: *"Assess a specified human-natural system for its vulnerability to climate change in the next 20 years and develop solutions that effectively increase the resilience of the system in the face of uncertainty."* The specific system to be assessed is given to the students and across the years has variously been the college itself or the regional system within which the college is embedded. Keeping the focal system local has proven to be critical for ensuring that students have access to the data, expertise, and stakeholders necessary to understand the system and effectively engage with the challenge within the limited time available in the semester. The challenge is specific enough to ensure that all teams are working toward the same outcome (e.g., resilience in the face of climate change) in the same system over the same time period, but also general enough to allow students to fully engage their creativity, both as individuals and as a collaborative team.

We believe that traditional practicums that treat the students as if they were consultants under contract to an external "community partner" to design a specific outcome (e.g., "design a communication strategy to promote bicycle transportation") have merit, but they do not allow students to practice skills necessary to see critical connections and leverage points that might yield more robust strategies. Therefore, we believe it would be a mistake to view it as the only, or even the best, pedagogical model for environmental practicums.

Through the application of systems mapping (part of the systems thinking toolbox), creative ideation (as part of the larger methodology of Human-Centered Design developed by IDEO [n.d.]), and scenario planning (discussed below), student teams develop an understanding of (a) the complete system in question, (b) the forces acting on the system, and (c) the certainties and uncertainties that may influence how the system will evolve over time. And further, with these understandings, students can harness their collective creative power to design implementable strategies to increase system resilience either by increasing the probability that favorable future scenarios emerge or promoting resilience regardless of how future uncertainties unfold.

The course culminates with each team making an oral presentation to a panel of external experts, arguing for the feasibility and value of their proposed innovation.

Over the four years we taught this practicum, no two teams have proposed the same ideas, even though each proposal – whether focused on a social or technological aspect of the system – would, if implemented, contribute to achieving the goal of the challenge.

Course Arc of the Sustainability Practicum

As noted above, scenario planning is integrated into our Sustainability Practicum as one of the planning tools to which students are introduced and expected to use to address the given

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challenge. The course meets formally three hours per day, three days per week, for six weeks, with many additional unscheduled hours expected as the students engaged in their team's research. The arc of the six-week course is as follows:

- *Week 1:* (A) Discussion of assigned readings to place the concept of sustainability into both an historical (Brundtland, 1987; Engleman, 2013) and global (Liu et al., 2007; U.N Department of Economic and Social Affairs, n.d.) context. (B) Training in systems mapping, including a field exercise and a tour of the sustainability features of the system that will become the focus of their research (e.g., the college and/or the region within which the college is placed).
- *Week 2:* Training in scenario planning (discussed in more detail below).
- *Week 3:* (A) Training in creative ideation as part of the Human-Centered Design methodology (IDEO, n.d.). (B) Formation of research teams (3-4 students each, structured to promote as much as possible diversity with respect to gender, race, geographic origin, collegiate affiliation, and dominant communication style as identified by the DiSC methodology (DiSC Profile, n.d.). (C) Project development (i.e., each team engages with systems mapping, scenario planning, and creative ideation as previously introduced).
- *Week 4:* Project development continued, with increasing emphasis on narrowing the focus of their work to identifying and developing a key strategy to meet the challenge. This work emphasizes literature reviews, stakeholder engagement, expert interviews, and creative adaptation of solutions from analogous systems.
- *Week 5:* Project development continued, with a focus on transitioning from research to communicating their proposal in writing as a group report and orally to a panel of outside experts.
- *Week 6:* Research presentations and completion of the written reports.

Other important skills, particularly effective strategies for working in a team (aka "teaming"), are introduced as part of a larger curriculum that includes students in all MSoE classes and therefore is not embedded specifically within the Sustainability Practicum syllabus. However, the students in the course are expected to incorporate teaming techniques into their work as research teams. This arc is readily adaptable to longer course timelines (e.g., a 15-week semester), as instructors can expand the amount of time allocated to any component. It should be remembered, however, that in the MSoE, this class has nine contact hours per week, which should indicate how much time we dedicate for each activity.

Scenario Planning

Each of the four skills employed in this course (systems mapping, creative ideation, teaming, and scenario planning) merits its own focus in a case study such as this. However, we focus in this paper on the use of scenario planning in a sustainability curriculum. We feel that, within the environmental educational community, it is not only the least well understood and

applied of the skills mentioned, but also because it offers an effective method for helping students envision and prepare for uncertain futures.

The fundamental methodology for scenario planning in the sense that we have used in our classes was developed in the early 1970's by Royal Dutch Shell PLC (aka Shell Oil) to help them develop business plans that would maximally protect the company's business interests in the face of future uncertainties in global energy markets (see Kleiner, 2003). Some of the people involved in that effort subsequently left Shell Oil in order to apply this methodology across a more diverse range of social challenges, including – and most notably – designing resilient sociopolitical pathways in post-apartheid South Africa (later referred to as the Mont Fleur process). (See Kahane [2004] for a more complete description of the history of the implementation of scenario planning to addressing sociopolitical challenges.)

Other domains to which scenario planning has been applied include economic development (World Economic Forum, 2018), educational reform (Knowledge Works Foundation, 2008; Rasmus, 2008), military preparedness (Larsen, 2019), geopolitical strategy (Ogilvy, 2015), transportation planning (Snyder & Sanborn-Stone, 2017), business planning (Wilkinson & Kupers, 2013), urban and regional planning (Goodspeed, 2020), and environmental planning (Than, 2016; Haigh, 2019). In each case, scenario planning was used to help stakeholders envision the uncertainties of the social, technical, environmental, economic, and political "landscape" toward which their planning was directed.

While scenario planning has been the focus of increased attention in education recently (e.g., Lopes, Clune, and Andrews, 2007; Varum and Melo, 2010; Wade and Piccinini, 2020), little explicit attention has been given to its relevance to education focused on environmental sustainability (see Hudspeth [2017] for an exception) or how it can be integrated into a skills-based environmental curriculum.

In some of these settings, the focus of planning was on being maximally resilient and *adaptive* across a range of possible futures (such as was the case with Shell Oil). In some, the focus was on being *transformative* (Kahane, 2012); since some of the possible scenarios might be deemed undesirable by those engaged in the process, scenario planning can help to identify conditions or events that would have to be true, and therefore how uncertainties would have to unfold, in order to manifest desirable and more resilient futures. This was the focus of the Mont Fleur process in South Africa, which helped representatives of the various political, social, and economic sectors of the country see what the consequences – both positive and negative – would be if various uncertainties were allowed to manifest in different ways.

Regardless of the purpose of the planning effort – be it identifying a business plan, political philosophy, environmental strategy, or some other focus entirely – the methodology involves six steps, listed here and subsequently described in more detail:

1. Identify driving forces for future changes;
2. Identify certainties for future conditions;
3. Identify uncertainties for future conditions;
4. Rank future uncertainties by the degree to which they might affect future conditions;
5. Create a grid of future scenarios based on the certainties and the two most influential uncertainties; and

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6. Describe the future world in each of these scenarios

As noted above, scenario planning is integrated into the arc of our course in two places: the training phase in Week 2 and the project phase, predominantly during Week 3. The steps followed are the same in both, but the question the research groups confront differs, as does the amount of time given for working through each step. In the training phase, the students are randomly placed in temporary groups of 3-4 and asked to address a question that is separate from the ultimate research challenge. The preliminary question we give them varies from year to year but relates to an issue with environmental relevance so that the students can bring to the process information they have learned in their previous environmental coursework. Two examples:

"How will changes in society over the next 20 years challenge the role of higher education in providing relevant learning that contributes to sustainable communities?"

"What kind of social-benefits corporation will be most beneficial in shaping the social, economic, and environmental state of the world in 2026?"

As previously described, the challenge presented to the formal research teams during the project phase is the following: *"Assess a human-natural system* (i.e., the college) *for its vulnerability to climate change in the next 20 years and develop solutions that effectively increase the system's resilience in the face of uncertainty."* Thus, the system (college), issue (climate change), general goal (resilience) and time frame (20 years) is specified for the students. However, the exact approach to promoting the goal within the system and time frame is not constrained, leaving the students free to explore any number of possible directions and innovations.

Implementation of Scenario Planning

Identify driving forces for future changes

With respect to the question or issue being addressed, students are asked to consider first the *driving forces* that are likely to influence conditions that might affect sustainability in meaningful ways in the future. At a minimum, starting with this exercise helps students think holistically about the world for which they seek sustainability solutions. They should consider several categories of important driving forces, especially those that are social, technical, environmental, economic, or political (referred to as STEEP Forces).

Each team is given a wall-mounted chart (Figure 1) onto which they collectively add notes about the forces that they identify. Students are encouraged *not* to edit themselves or others as they add notes; all ideas are valid in that they provide a diverse background picture of what might shape the future without an *a priori* filter on a particular aspect of sustainability (e.g., equity, water, food, or climate). Ranking how influential a particular driving force might be is not necessary. As examples, driving forces that have been identified by our students include the degree of gender and racial equality in social and political spheres, robotics in the workplace, dependence on fossil fuels, the use of nuclear power, and the magnitude of global trade.

Figure 1

Driving forces step in Scenario Planning: (A) Wall chart with student additions; (B) Students collaboratively considering the relevant driving forces.

The value of engaging the students with this step is to allow them to reflect broadly about what might shape the future. We explicitly encourage them to bring to this step what they have learned in their previous courses, and since each student is likely to have studied different topics, this step gives them the opportunity to learn from each other and strengthen their sense of collaboration. We allocate approximately 20 minutes to this step in the training phase, and an hour or more (depending on their progress) in the project phase.

Identify the certainties for future conditions

Students are then asked to consider – in the context of the driving forces they identified – the certainties for the future. In other words, what does the future hold regardless of what else may or may not occur. Clearly, "certainties" could always be negated by unpredictable events, such as large asteroid strikes or (as the world has recently seen) the emergence of a global pandemic. In this step, something is considered certain or not within the range of probable conditions and trends. For example, it is a certainty that global human population size will continue to increase until at least the middle of this century and average global temperatures will continue to rise.

As with the previous step, students use sticky-notes attached to a wall to collaboratively develop a list of certainties. A certain amount of group editing is inevitable, as they discuss whether they collectively feel that a particular suggestion is, indeed, a certainty. This process tends to help students discern and organize the granularity of the forces they identified in the previous step. For example, "access to affordable health care" is a different type of driver than "political makeup of Congress." It also helps the group make more explicit their definitions of

what goes where with respect to the STEEP categories, e.g., is "affordable health care" an economic driver or a social driver? Why did we make it one or the other?

Because the project challenge we give to the students relates to climate change, we foreshadow this step earlier in the semester by having them read and synthesize the most current climate assessments for our region (e.g., from the Fourth National Climate Assessment [U.S. Global Change Research Program, 2018]). This focuses the students' thinking into the domain of the challenge without preventing them from thinking more broadly, as well as helps them think about the probability of specific consequences of climate change (e.g., increased summer precipitation, increased ocean acidity).

We allocate approximately 15 minutes to this step in the training phase, and an hour or more (depending on their progress) in the project phase.

Identify the uncertainties for future conditions

Students are then asked to consider the uncertainties for the future. Uncertainties are events or outcomes that *might* happen or have a likelihood of happening in a number of different ways. Which political party will lead the Executive Branch of the U.S. government after the next general election? Will economic inequality in the U.S. change? Will a cure for cancer be developed? Will life be found on Mars? The answers to these questions are presently unknown, and a case could be made for any one of a number of possible answers.

Students once again use sticky-notes applied to a wall, generally next to but separated from their column of certainties. While uncertainties can be phrased in a number of ways implying different degrees of specificity, it is important in this step that they be phrased without assigning a particular direction, value, or outcome. As will be seen in a subsequent step, "will inequality change?" is better for this step than "will inequality increase?" and "what will the future primary energy source be?" is better than "will fossil fuels be phased out?"

Rank future uncertainties by the degree to which they will affect future conditions related to resilience

Students are then asked to sort through their uncertainties and organize them based on their perception of how much impact the specific outcome of that uncertainty will influence society in the future. For example, both the outcome of the next presidential election and the next World Cup are equally uncertain, but they are not equivalent in terms of their overall future consequences for society.

This step can be the most challenging for students, as for the first time in this process they need to explicitly rank one suggestion against another, and they should be given as much time as they need to work through this. In our experience, their progress is improved by (1) reminding them to reflect back on the overall challenge/question their scenarios will be about to help contextualize this step; and (2) encouraging them to sort the ideas into three categories: highly influential, weakly influential, and everything in between. Once they reach agreement on which uncertainties are highly influential, they can focus their efforts on ranking only those, as the uncertainties in the other two categories do not need to be ranked.

At the end of this step, each team should have a STEEP wall chart that describes the critical forces at work in the world relative to shaping a sustainable future, accompanied with a section of wall that has sticky-notes arranged in two columns: certainties and uncertainties. The uncertainty column is further subdivided into its three categories of degree of influence.

Create a grid of future scenarios based on the certainties and the two most influential uncertainties

Using the list of highly influential uncertainties, each team should select the two that they feel are the most likely to affect future conditions. For each, imagine a spectrum ranging from one extreme outcome to the opposite extreme. For example, it is uncertain what the primary fuels for generating electricity will be over the next 50 years. One extreme could be "complete dependence on fossil fuels," and the opposite extreme could be "complete dependence on renewable fuels, such as wind and solar." This step avoids the application of any *preference* for an outcome; it merely identifies the spectrum of possible outcomes for the two uncertainties considered the most influential on the future. In addition, it avoids arguing for one or the other of the extremes, as both extremes could be considered equally unlikely, but the two together set the limits of a spectrum of possible outcomes.

The students should then envision separately the full spectrum of each of these two uncertainties as an arrow and draw the two arrows orthogonal to each other (Figures 2 and 3). This creates a grid with four quadrants, and each quadrant is a unique scenario described by the possible outcome of each of the two uncertainties. In addition, each scenario is also described by the same set of certainties.

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Figure 2

The grid of four scenarios created by the orthogonal arrangement of the full spectrum of possible outcomes for two critical uncertainties about the future. Note that the certainties are present in all four scenarios.

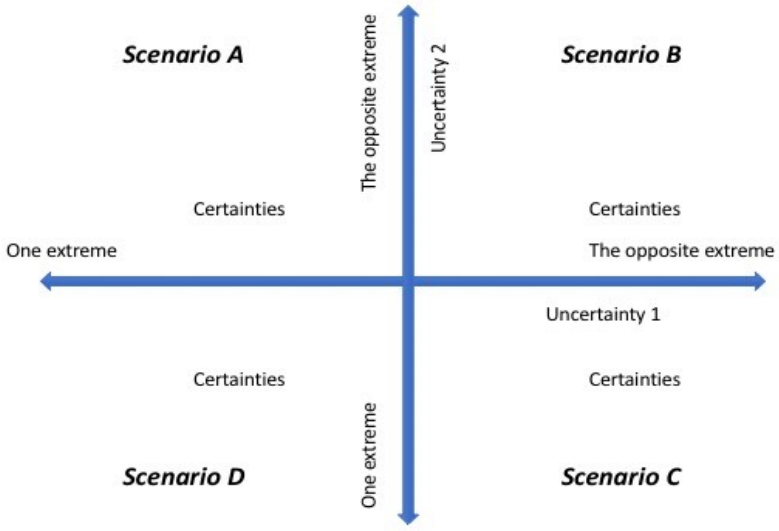


Figure 3

Students working on a wall chart to create their four future scenarios.

In the absence of any assigned probabilities to possible outcomes, each scenario is an equally probable future. Together, they provide a more robust view of the possible *futures* (emphasis on the plural) that need to be considered when planning for the future, regardless of the focus of the planning.

Describe the future world in each of these scenarios

Now that the students have shaped four dominant scenarios for the future, inarguably defined by what they each decided were the certainties and most influential uncertainties about the future, they can flesh out what those scenarios might be like. This step creates the basis for their subsequent creative thinking about strategies to maximize resilience across multiple scenarios (adaptive planning) or to maximize resilience by influencing the probability that a preferred scenario prevails (transformative planning). It also gives them material to use as context in their final written and oral presentations for why their proposals have merit: their presentations describe not only the basis for and feasibility of their idea but also the role that the idea can play in increasing resilience for an uncertain future.

Several different tools can be applied in this step to stimulate the students' creativity and engagement, based on the time that can be allocated to it in the course arc.

1. Scenario names and descriptions: Give each scenario a name that reflects – explicitly or whimsically – the kind of world it is given the certainties and the extremes of the two uncertainties. Writing a narrative of 100-200 words describing each scenario guides the students to reflect more fully on what that future might look like. When the available time for this step is short, the students can focus on naming all four quadrants but writing narratives for only two.
2. Future Front Page: Using a specially formatted wall chart (Figure 4), students can create the front page of a newspaper for each scenario, describing the kinds of newsworthy events, both positive and negative, that might take place there.
3. Future Wheel: We also provide students with a Future Wheel template they can use to play out how some of their uncertain driving forces might lead to subsequent changes (Figure 5). A future wheel starts with an uncertain driving force at the center with first, second, and third-order consequences radiating out from there. Students are encouraged to see these consequences as cause and effects and are encouraged to focus on causality and not on chronology. For example, increasing taxes on business followed by fewer small businesses may be more chronological than causal. A better way to state this, focusing on causality, would be: increasing taxes on business followed by small businesses lobby for tax breaks.

Examples of Scenario Planning implementation

Figure 4

A hypothetical front page of a newspaper in the future world described

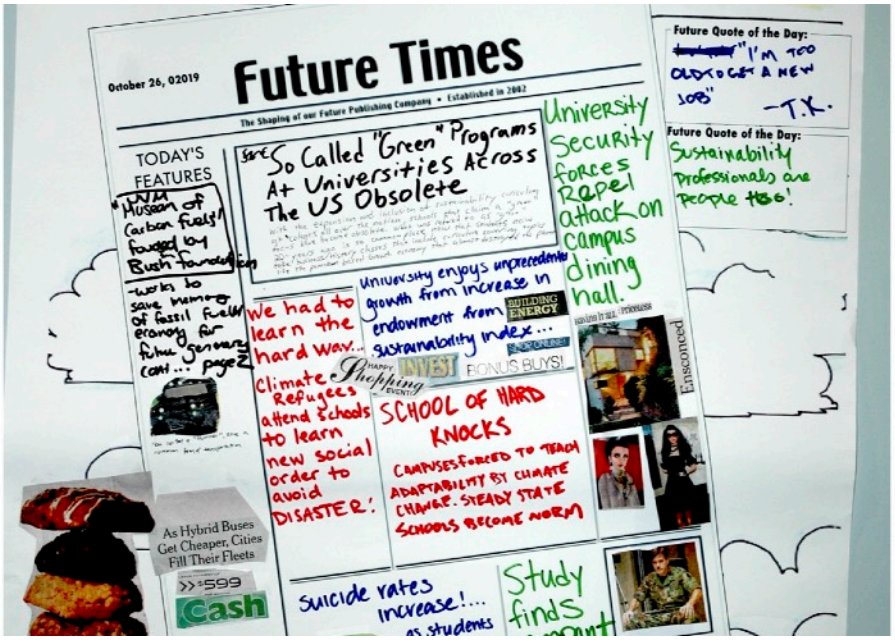
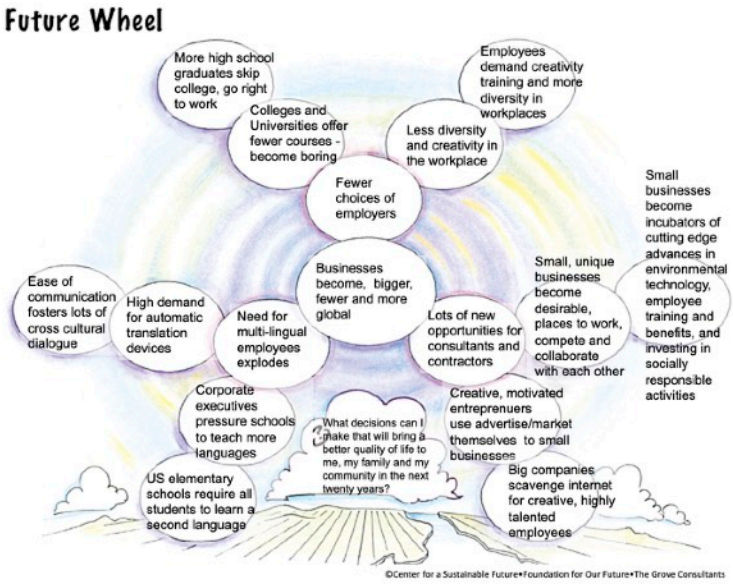


Figure 5. Figure 5. A completed future wheel starting from a driving force where "businesses become bigger, fewer, and more global," with subsequent consequences (each of which serving as forces themselves) radiating outward. (Used by permission from the Foundation for Our Future.)



As we argued before, the curricular arc of this course is less about teaching students to be effective contractors on specific projects but more about being holistic and creative thinkers regarding larger challenges. In the years we have offered this course, no two student teams developed the same outcomes from their use of scenario planning, nor with the same ideas for how to promote resilience in the face of climate change. One example from among many serves to illustrate the possibilities. The students in this team – comprised of two women and one man, each a rising senior from a different college in geographically diverse locations and with different majors (conservation psychology, global health, and international studies) – were given the challenge to assess the college-town regional system for its vulnerability to climate change. Using the scenario planning methodology, they developed the following responses to Steps 2-6, focusing strongly on certainties and uncertainties related to climate change itself:

Certainties

Based on both the National Climate Assessment (U.S. Global Change Research Program, 2018) and the Vermont Climate Assessment (Galford et al., 2014), some consequences due to climate change are highly certain to occur or will continue to occur no matter how the future unfolds. Both assessments identify severe weather, including hurricanes and floods, as likely to increase in frequency in this region as climate change continues to progress in the next 20 years. Identified certainties include the following: increased runoff and contamination in sewers, increased property damage, increased energy use, increased pathogen damage to crops, and increased access to computerized technology.

Uncertainties

Many of our uncertainties relate to severe weather events increasing as a result of continued climate change. These include the following: access to resources for adaptation and mitigation, degree of social cohesion, inclusion of vulnerable communities in hazard planning, independence of energy and food supplies from long transportation requirements, vulnerability of transportation networks, engagement of non-profit organizations in disaster relief, adequacy of water treatment facilities to increased storm water flow, and resilience of communication infrastructure.

Two Most important Uncertainties

The two uncertainties that we think will have the most influence on future resilience are (1) access to resources for adaptation and mitigation, and (2) degree of social cohesion.

Four Future Scenarios

Based on these two key uncertainties, four scenarios are revealed by the two axes (Figure 6). The horizontal axis is Degree of Social Cohesion, with its two extremes characterized as

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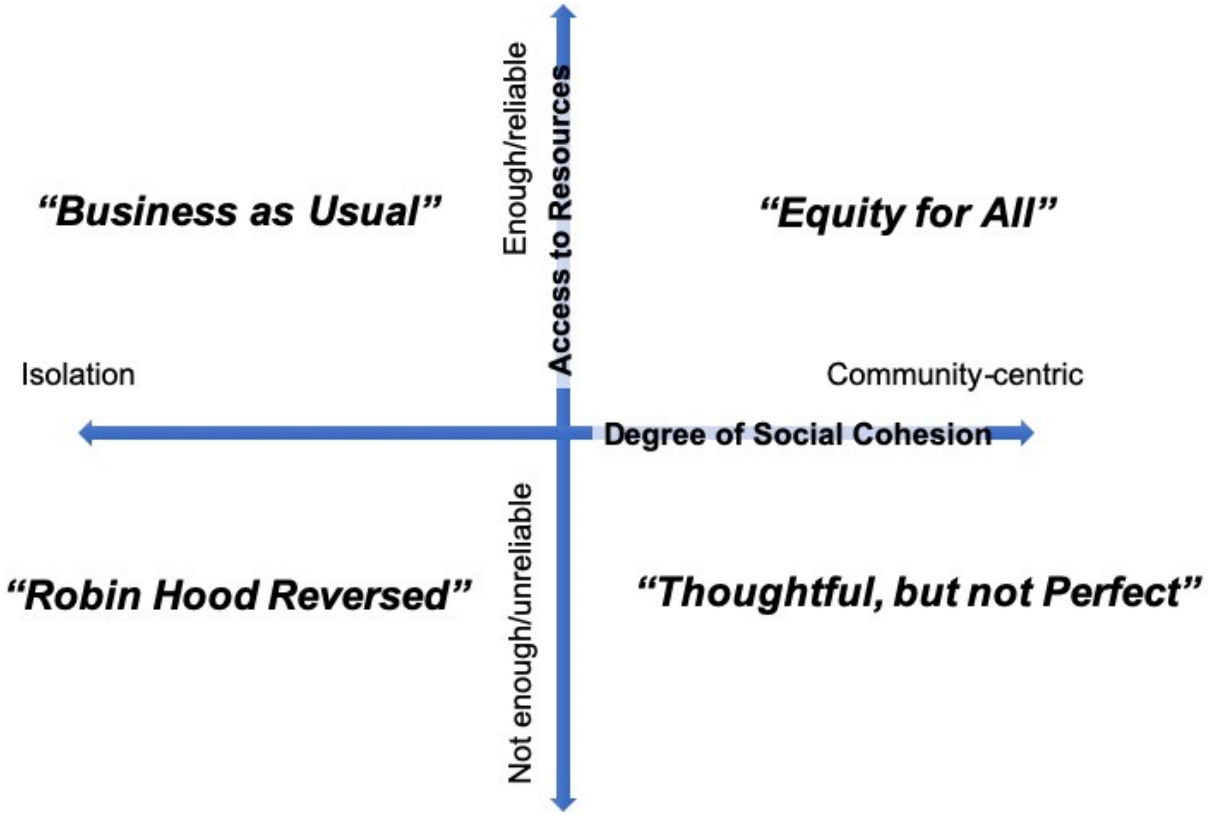
Isolation (signaling an "every person and organization for themselves in the face of climate-related disasters) and Community-centrism. The vertical axis is Access to Resources, with its extremes Enough/Reliable and Not Enough/Unreliable.

Figure 6

Four scenarios created by the two orthogonal axes — degree of social cohesion and access to resources — each with two extremes of expression.



Scenario Names and Descriptions

"Equity for All" This future is characterized by high security of resources and access to those resources for everyone in the college and town communities. There is mutual reliance between town and the higher education institution, which leads to open communication and being cognizant of each other's needs in order to overcome barriers that separate the two communities from functioning as one in the face of a climate crisis.

"Business as Usual" This future operates around a hierarchy of access based on wealth and ranking within Middlebury College. Students, faculty, and staff at the college will have access to and security of resources, but this bioregionalist, power-based structure may lead to

the overconsumption of available resources by some at the cost of the wellbeing and needs of others, specifically within the town.

"Robin Hood Reversed" This future does not have the capacity to sustain both the town and the college due to limited access and availability of resources. This means that each community will be fending for itself and will act independently of the other. One community could end up being resilient at the expense of the other, but there is a chance that both communities will experience suffering.

"Thoughtful, but Not Perfect" This future is characterized by uncertain resource security and access but results in resource distribution that most effectively meets the needs of everyone in the larger college-town community of Middlebury to the best of its ability. However, this future has the potential of suffering and dissatisfaction in order to distribute supplies and materials to everyone regardless of socioeconomic and other status-identifying factors.

What Follows from Scenario Planning

Simply developing the four future scenarios alone will not effectively increase resilience in the face of uncertainty. The next tool that students apply to meeting the challenge is that of creative ideation, integrated into our curriculum in Weeks 3 and 4. (A detailed description of this methodology is beyond the scope of this paper, but interested readers are encouraged to read the Human-Centered Design toolkit developed by IDEO (n.d.) that describes its implementation for their work in community development.

For our students, the use of creative ideation begins with assessing the four scenarios in terms of whether some should be avoided through a focus on influencing the outcomes of the key uncertainties. Once a team decides this, it can focus its future work on identifying strategies that are maximally useful across multiple scenarios (adaptive planning) or those that are likely to influence one or both key uncertainties in a preferred direction (transformative planning).

In the example give above, the students decided that the "Equity for All" scenario was preferred, and therefore they focused on ideas that would help shift the degree of social cohesion to the right and access to resources upward. After much research and interviews with key community leaders, their ultimate recommendation centered on the development of a community-based, digital platform providing information on flood risk, preparation, and response. This platform would be structured in a way to allow members of the community to share ideas, stories, and opportunities to become involved in proactive and community-centered disaster planning.

Other teams working on the same challenge over the years, following the same methodologies, have advanced a wide variety of strategies that range across both social and technological domains. These include the development of a local microgrid, installation of a flexible rainwater harvesting system, regional support for provisioning manure for biomethane

production, creation of new curricular opportunities on campus to study systems resilience, improvement in regional green infrastructure to help control stormwater discharge and promote safe non-motorized transportation, development of a regional food hub, transformation of zoning incentives for sustainable housing clusters, installation of smart water metering systems, use of algae for biomass energy production, and enhanced opportunities for local food production.

After student groups presented their ideas to a panel of outside experts (Week 6), each proposal was subsequently delivered to the relevant committee, department, or board for further consideration for implementation. Many of the recommendations made by the teams have — in whole or part — been implemented, including (a) the creation of a Sustainability Solutions Lab, which supports students to generate and implement ideas to make the college more sustainable and resilient; (b) a partnership with the New Perennials Project, which is focused on helping build perennial and regenerative agriculture in the bioregion through multiple channels: science, culture, reflective pedagogy, and the arts; and (c) The Townhouse Energy Monitoring project, which has served as a test bed for research by psychology, computer science, and economics students and faculty on energy conservation behavior in general and reduced energy use in some student residential units. Other recommendations have been integrated into larger projects that are still in the planning or permitting stage, such as the addition of a 2mW battery storage facility associated with a 5mW solar array, presently in the construction phase, to modulate power demand and provide emergency power during an outage.

Lessons Learned

Over the years, we have adapted our approach in response to implementation and learning outcomes from previous years. We have learned that attention needs to be paid to these points to improve the quality of the experience for students.

- Adjust the time for each step to match the total available time for the method.
- Schedule time for class reflection between critical steps so students can deconstruct and correct problems encountered at each step, are clear on what they accomplished, and how it will support subsequent steps and move them toward the final goal.
- Make clear at the start the rules for defining and expressing certainties and uncertainties, (i.e., certainties have known direction and trend, uncertainties don't).
- Allow plenty of time for students to identify and revise uncertainties; naming critical uncertainties in a way to be useful for scenario planning requires practice.
- In describing scenarios, keep the students' attention on the certainties as well as the uncertainties; each scenario is defined as much by the certainties as by the unique combination of how the two uncertainties are manifested.
- Encourage students to be explicit about how their potential solutions (emerging from subsequent creative ideation) relate to one or more scenarios, either in an adaptive (effective in two or more scenarios) or transformative (driving future outcomes toward a preferred scenario) way.
- Ensure that the students see the method of scenario planning as being separate from its historical origins (as a tool developed by Shell Oil) or its representation as an extension

of colonialism (e.g., people from more developed countries "helping" those in less developed countries).
- Deconstruct the method *post facto* to help reconstruct its broader utility for other settings and challenges students might confront in other classes or in their later professions.
- Encourage students to reference the results of their scenario planning process in reports — oral and written — that emerge from their work in order to provide the context for how their proposed solutions contribute to achieving the challenge given to them and increase the likelihood of implementation.

In summary, scenario planning is a useful skill applicable across many domains. Its value in a sustainability curriculum is particularly great given the inevitable intersectionality of effective sustainability solutions and the need for robust consideration of temporal and spatial scope. This case study exemplifies one possible way to integrate training in scenario planning into an undergraduate environmental curriculum. The specifics of the curriculum presented here were designed to meet the opportunities and constraints provided by the design of the Middlebury School of the Environment. However, this curriculum can easily be adapted to integrate scenario planning into other curricular designs, particularly those scheduled across longer terms or with more opportunity for engagement with the literature.

Regardless of the specific curricular framework for a course, inclusion of scenario planning offers students a valuable tool for addressing *any* challenge in a way that emphasizes creativity, collaboration, expansive thinking, and awareness of leverage points for making the world a better place.

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