What Lies Beneath? A Systems Thinking Approach to Catalyzing Department-Level Curricular and Pedagogical Reform through the Northwest PULSE Workshops

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Abstract
We have developed and tested a dynamic approach to assist positive, department-wide change at institutions of higher education. Here we describe a workshop strategy designed to empower faculty as agents of change. This strategy incorporates tools and concepts including systems thinking, visual facilitation, and action planning to drive transformation at the department/program level. Although our workshops were developed for life sciences faculty, the processes we adopted, and the lessons learned from the project, provide a framework for the faculty of any STEM discipline at any type of higher education institution to develop skills to effect changes in approach

and pedagogy that will improve learning outcomes. While our workshops were carried out in person, we describe approaches that can be adapted for online use.

Keywords
curricular change; systems thinking; Vision and Change; workshop; professional development; department transformation

Introduction

Evaluating, transforming, and modernizing departmental curricula are crucial endeavors, especially in this time of upheaval in higher education. Changing enrollment patterns (e.g., Kim et al., 2020) and student demographics (e.g., National Academies of Sciences, Engineering, and Medicine [NASEM], 2018), coupled with funding declines (e.g., Mitchell et al., 2017) are just a few of the changes influencing higher education today. The COVID-19 pandemic has added further complexity. Within this environment, regular revision of curricula and practices is key to remaining current with disciplinary and interdisciplinary content and to effecting positive student outcomes. Meaningful change, however, is often difficult for higher education departments and programs to achieve.

In institutions of higher education, curricula and pedagogies are generally controlled by discipline-based departments or programs. The structures of many disciplinary curricula were established early in the 20th century and have typically undergone little change over time, even as knowledge in every discipline has expanded and deepened (National Research Council, 2012). Either new knowledge and revised interpretations of existing facts are integrated into courses that have existed for years, or new courses are inserted into existing curricular structures. Rarely do departmental faculty reflect on whether the curricular sequence, the types of courses offered, the progression of topics within a course sequence, and/or teaching strategies that may have been in place for decades are effective for achieving positive learning outcomes (Tagg, 2012; Wieman, 2017). In addition, some courses are considered the province of individual instructors who may revise or restructure their courses without reference to how well those courses fit into the departmental curriculum.

In the life sciences, a series of workshops and conferences in the late 2000s culminated in the publication of *Vision and Change in Undergraduate Biology Education: A Call to Action* (American Association for the Advancement of Science [AAAS], 2011), a compendium of research-based practices for engaging students in learning the life sciences, focusing on conceptual understanding, development of relevant skills, student-centered pedagogies, and a campus-wide commitment to change. The *Vision and Change* recommendations were designed to transform undergraduate life sciences education for the 21st century; their adoption thus requires negotiation among all department members, a task for which many faculty members may be ill-prepared (Brownell & Tanner, 2012).

While faculty members are highly trained experts in their fields, often having strong identities shaped by the "rules of membership" of their specific discipline (Brownell & Tanner, 2012), they are not typically knowledgeable about leading change at the department or program level. In addition, such concerns as lack of time for innovation, perceived competition between research

and teaching in institutional reward structure, and desire to cover large amounts of material in a course can serve as barriers to curricular reformation (Petersen et al., 2020; Shadle et al., 2017). Therefore, faculty members may be resistant to changes in curricular structures and teaching practices, especially when those changes are externally imposed (Tagg, 2012). These barriers to change often impede the implementation of new and effective pedagogical approaches (Kezar et al., 2015; Kezar & Gehrke, 2015).

To promote the *Vision and Change* recommendations, several national agencies—National Science Foundation (NSF), National Institutes of Health (NIH), Howard Hughes Medical Institute (HHMI)—formed the Partnership for Undergraduate Life Sciences Education (PULSE) and recruited 40 Leadership Fellows to identify strategies that would accelerate the adoption of the *Vision and Change* recommendations by life sciences educators nationwide. The PULSE Fellows chose to focus their efforts on effecting change at the departmental (rather than individual) level because departmental curricula and pedagogies are controlled by faculty groups, while individual faculty members often control only their own courses.

The PULSE Fellows in the Pacific Northwest (NW PULSE Fellows), obtained funding from the NSF to deliver workshops that empower faculty members to become agents of effective change in their home departments in order to develop common curricular and pedagogical goals, improve group dynamics, overcome barriers to modernization, and create an overarching vision for departmental transformation. We reasoned that faculty members are typically more open to suggestions for implementing new pedagogical approaches from colleagues in their departments (due to shared "rules of membership"). To that end we recruited teams of life sciences faculty members and administrators to attend a workshop focused on developing attendees' skill in and knowledge of how to leverage organizational change. To do this we used systems thinking, a successful strategy for effecting organizational change adopted from business and other fields (Capra & Luisi, 2014).

Academic institutions and the departments within them are, like all human organizations, complex systems. In a complex system, cause and effect may not be closely coupled, feedback is more likely to be delayed rather than immediate, and unintended consequences emerge as a result of any decision or intervention (Kezar, 2009; Kezar, 2013). Understanding and changing the behavior of an organization requires that the change agent bring a systemic perspective to the work (Austin, 2011; Manning 2013). Senge describes systems thinking as a discipline for seeing wholes, thus generating the understanding that "the whole can exceed the sum of its parts" (Senge, 2006, p. 12). In contrast with analysis, a way of thinking that seeks understanding by examination of component parts, systems thinking addresses how components are *interrelated* and how they interact over time. Thus, systems thinking brings about understanding of the behavior (outcomes) of a system as a whole. Without such understanding, efforts to intervene and change a system may be ineffective or even counterproductive.

We selected the systems thinking approach for supporting implementation of the recommendations of *Vision and Change* because agents of departmental change who apply systems thinking principles are more likely to devise and sustain successful interventions (Austin, 2011). We devised a set of systems thinking concepts that could be presented within the time constraints of a three-day workshop and still sufficiently ground the participants in a systemic mindset. The

workshop, in conjunction with pre- and post-workshop activities, allowed participants to develop tools to immediately begin implementing a customized departmental change process.

We note that the workshop model we describe can be offered in person or online and for varying lengths of time. While we focus on departments/programs in the life sciences, the workshop model is applicable to other science disciplines—our workshops included participants from STEM disciplines such as chemistry and mathematics. Given the broad applicability of systems thinking, we anticipate this model would be beneficial for participants from non-STEM disciplines as well.

The Workshop Model

Our approach involved a three-day, in-person workshop for teams of faculty and administrators from life sciences departments, predominantly from the Pacific Northwest. Below we elaborate on some of the key elements used to implement this process over five successive annual cohorts of participants (from 2013–2017). Most of the workshop components can be adapted for use with web-based conferencing coupled with shared online workspaces and can be offered over varying time frames.

Pre-workshop Practices

The Planning and Implementation Team

In addition to the NW PULSE Fellows, our team included a steering committee of three individuals with experience in curricular and organizational change. We also included two systems thinking experts and a visual facilitator, all with years of experience in facilitation. This intentional inclusion of expertise from multiple perspectives and disciplines (e.g., life sciences, systems thinking, facilitation, and higher education change management) led to the overall design success of our professional development experience and subsequent change efforts enacted by participants. The variety of expertise offered during planning allowed the team to develop a number of different approaches to maximize effectiveness during the workshop.

The planning and implementation team members were representative of all higher education institution types in the region (e.g., community colleges, liberal arts colleges, regional comprehensive universities, and doctorate-granting research universities). We employed this inclusive approach to help workshop participants, themselves from a variety of institution types, identify and engage with the facilitators and envision themselves as change agents in their institutional context.

For the first two years the planning and implementation team members met for a two-day, in-person planning meeting. In subsequent years, all of the planning and implementation team's work was conducted through online video conferencing. This included integration of new planning and implementation team members, for whom all the planning work was conducted exclusively online.

Participant Selection

We invited applications from all higher education institutions in the Pacific Northwest (i.e., Alaska, Idaho, Montana, Oregon, Washington, and Wyoming) that offered programs in the life sciences. The application included a team component as well as a section for each team member

(Table 1). Through a deliberative video conference meeting process, we selected teams whose applications demonstrated a capacity for strategic planning in support of departmental change. For example, we selected teams who identified departmental change goals and student-centered objectives. We preferred teams of at least three members, with one of the participants having an administrative role at the level of department chair or above. Participation by and support from institutional leadership are important factors in advancing strategic change (Austin, 2011; Reinholz & Apkarian, 2018). We also encouraged teams to include non-tenure-track, contingent, and/or part-time instructors. Through the selection process we ensured that each cohort included teams from a broad range of institution types.

Table 1

Questions included on the workshop application.

Team Application	
1.	Please describe why you believe that your department is ready to embrace a strategic planning process to improve undergraduate education in the life sciences consistent with the AAAS Vision and Change (V&C) Report.
2.	Please describe why the composition of your team is appropriate for strategic change in undergraduate life sciences teaching and learning at your institution.
3.	Briefly describe what goals your departmental team hopes to achieve, work on, or develop as the result of your participation in this workshop.
4.	We understand that if selected to participate in the workshop, each member of our team will commit to completing pre–workshop activities. These will include each institutional team using the V&C document and a series of PULSE rubrics (see PULSECommunity.org for more information) to assess the current status of their department. Are you able to commit?
5.	We understand that if selected to participate in the workshop, one member of our team will commit to attending the follow–up symposium at the NW Biology Instructors' Annual Meeting in May 2016. Are you able to attend?
Team Member Application	
1.	Please list the courses you have taught in the last 5 years and their levels. Also, please indicate your role in the course (lecturer, TA, organizer) and the course size.
2.	Please discuss your motivation(s) for attending this workshop. What you would most like to accomplish, begin, and/or learn? Have you incorporated any of the recommendations in the Vision and Change document into your teaching? If so, which ones? How will your team's participation in this workshop serve your own teaching and your students?
3.	Please describe a previous faculty development activity, workshop, or conference that has changed how you teach and has the potential to affect others in your department.

4.	I understand that if selected to participate in the workshop, I commit to attending the entire workshop.

Initially, not all applicants were accepted. For example, some applicant teams sought a pedagogical professional development workshop rather than a departmental transformation focus. After three years, as fewer institutions applied, we actively recruited applicants, allowed some institutions to participate for a second time (usually with different team compositions), and allowed select teams from beyond the Northwest to participate. By the end of the five years of workshops, approximately 40% (63/148) of all institutions with life sciences departments/programs in the Northwest region, and four teams from outside the Northwest, had participated.

Pre–Workshop Activities

An NW PULSE Fellow or steering committee member was assigned as a coach for each team (Czajka & McConnell, 2016), based on similarity of institution types and/or geographic proximity. The coach was the point of contact prior to the workshop, worked with the team during the workshop, and routinely followed up with the team throughout the subsequent year. During the workshop, coaches were also called on to work with teams other than their own as their expertise warranted. All pre- and post-workshop interactions among coaches and teams were conducted via email and/or video conferencing.

In the month preceding the workshop, coaches prepared the teams through weekly emails that described introductory work (Table 2). Activities included relevant readings, a short video about systems thinking, a questionnaire about the team's department, and assessments of the alignment of the team's department with the recommendations of *Vision and Change* using the PULSE rubrics (Aguirre et al., 2013; Brancaccio-Taras et al., 2016).

Table 2

Pre-workshop activities.

Week	Content
1.	**Preparing your team for systems thinking.** Materials: *Using Systems Thinking as a Foundation for Thinking about Vision and Change*; Peter Senge video describing systems thinking; "Habits of a Systems Thinker" summary (Waters Foundation); excerpt from *Promoting Evidence–based Change in Undergraduate Science Education* (Austin 2011); *Vision and Change* executive summary.
2.	**Information about current department climate.** Link to an online survey for each team member. The survey included questions about departmental climate such as existing support for change, strategic pedagogical planning, and current curriculum alignment with *Vision and Change* recommendations.
3.	**Current department alignment with *Vision and Change* recommendations.** Each team member completed PULSE rubric(s) individually [see "Rubrics" section].

4.	Review of pre–workshop activities and distribution of workshop agenda.

Workshop Structure and Selected Components

The three-day workshop was held annually over a weekend in October (see supplementary material for a sample agenda). Workshop activities ranged from short informational presentations by our planning and implementation team or guest speakers to institutional team–based activities. During these activities, teams assessed their department's current state and planned how to achieve a desired future state. Because of the COVID-19 pandemic, workshops similar to ours have been successfully conducted by other PULSE groups online. We note, therefore, that most of the activities we describe below can be carried out in an online format.

At the outset of each workshop we included a discussion of guiding principles to establish a collaborative learning environment (e.g., informality, curiosity and learning, mutual support, nobody speaks twice until everyone speaks once), and we invited participants to maintain an abundance mentality. The concept of an "abundance mentality" (Covey, 1989) encourages participants to think about what they can accomplish with the assets available to them, rather than focus on the limitations imposed by resource constraints. We reminded participants of their commitment to be fully present, and to attend to the workshop activities, throughout our time together. These guiding principles apply to both in-person and online formats.

Intentional Learning Environment

All workshop operational elements—location, setting, graphics, activities—were designed to enable participants to experience a sense of welcome and connectedness. For example, we arranged the main meeting room to encourage connection and conversation, using round tables rather than theater-style seating. When the participants arrived, the walls of the main meeting room featured large, colorful, hand-drawn graphics, prepared in advance by the visual facilitator. The graphics represented topics such as the geographical locations of the participating institutions, participants from previous cohorts (after the first year), and a workshop roadmap (graphical agenda).

Deliberately preparing the learning environment, for either in-person or online workshops, sets the tone for participant participation and expectations (Ebert-May & Hodder, 2008). Participants should be engaged from the outset and develop a collaborative mindset. For workshops offered online, we anticipate that background graphics, a graphical agenda, and similar components will help create an active, and interactive, online environment from the start of the first session.

Visual Facilitation

Visual facilitation (Winkel & Junge, 2012) is a method for capturing ideas, concepts, and conversations in pictures and keywords in an engaging way (see Fig. 1). It is more typical to use notetakers or audio recordings for documentation in an academic environment; however, it can be difficult and time consuming to extract key ideas from these documents. We elected instead to use a visual facilitator for each workshop based on our prior experience with the effectiveness and

immediacy of this approach for both in-person and video conferences. Our judgment was confirmed when participants rated this feature of the workshops highly.

Figure 1
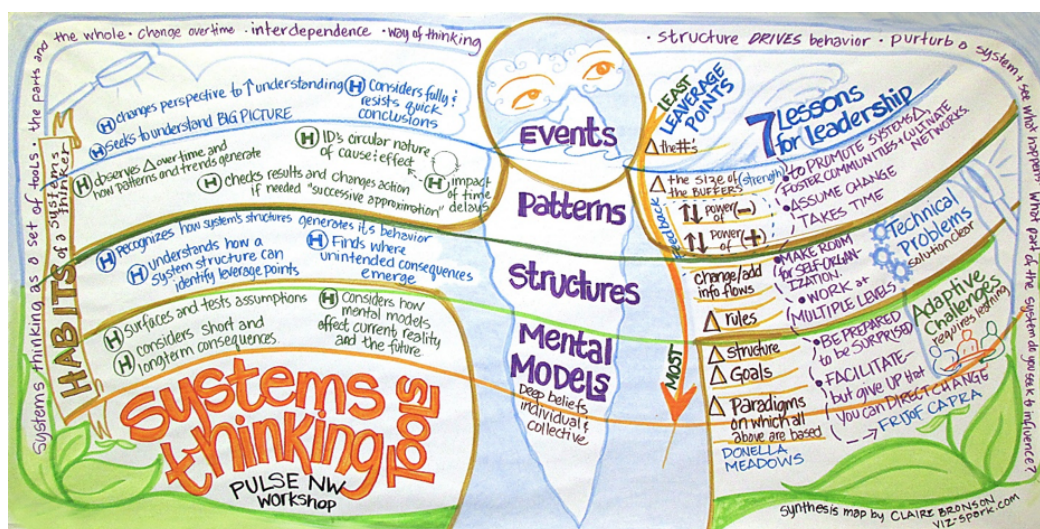
Example of a visual facilitation product from a workshop session; this graphic illustrates the iceberg metaphor.

The visual facilitator developed large illustrated posters that reflected the objectives and outcomes of each workshop activity. In addition, the visual facilitator guided participants to create their own graphical images to share with their departments (see "Vision Exercise" below). All posters prepared by the visual facilitator were displayed on the walls of the meeting room. Following the workshop, the posters were converted into a digital pdf file that was distributed to all attendees and posted on the NW PULSE website. Visual facilitation could be conducted in real time during online sessions via shared screen capabilities and/or the products displayed in shared online repositories.

Visual facilitation has been shown to increase teamwork, perceived team creativity, and satisfaction with teamwork (Eppler et al., 2013). The feedback from our participants and planning team confirmed that visual facilitation helped clarify thinking about complex and nuanced ideas, increased understanding, and tapped into creative ways of thinking not traditionally employed in academic or professional settings. Furthermore, the digital pdf files provided easily accessible ways to both recall information and share it with others who were not present at the workshop.

PULSE Rubrics

To facilitate meaningful discussion within teams about the current state of their department, we used the PULSE Vision & Change Rubrics (Aguirre et al., 2013; Brancaccio-Taras et al., 2016) which evaluate department/program alignment with *Vision and Change* recommendations in five broad areas: curriculum, assessment, faculty practice and support, infrastructure, and climate for change. A briefer *Snapshot* rubric encapsulates elements from each of the five longer rubrics. The rubric criteria designate different levels of implementation of *Vision and Change* principles from first steps to full departmental transformation. While the concepts section of the *Curriculum*

Alignment rubric is specific to life sciences, the competencies section is relevant to all science departments and many non-science disciplines. The remaining four full-length rubrics, and the *Snapshot* rubric, are relevant to academic departments of all disciplines. The rubrics are available for access online (PULSE Community, 2020).

As part of the pre-workshop activities, each team member completed one or more of the PULSE rubrics. During the workshop, participants discussed their individual rubric scores with other members of their departmental teams. These discussions often revealed differences among team members' views that sparked fruitful conversations about the origins of the differences. This range of scores often reflected differences in understanding or knowledge of the department or curriculum by the group members, leading to productive discussions about the reasons for the variation in the scores they assigned. The discussions also revealed areas of agreement about where the department's level of achievement was strong or where the level of achievement was lower than desired. The team's coach then facilitated a discussion to achieve a team consensus that reflected the current department state and identified potential areas for change that could be addressed in the subsequent planning process. Breakout rooms during video conferencing, coupled with the online rubric format, would provide a useful alternative approach for team discussion and consensus building using the PULSE rubrics.

Triangles

To provide participants with a concrete experience of the unpredictable nature of complex systems, we used an engaging and useful kinesthetic group activity called Triangles, from *The Systems Thinking Playbook* (Sweeney & Meadows, 2010). Briefly, starting from a circular arrangement, each participant secretly chooses two others and attempts to position themselves equidistant between the two. As participants all move to align themselves, an order is established and disrupted repeatedly. Through the exercise and debriefing, the participants experienced how systems are dynamic, how their parts are interdependent, how changes in one part of the system can have effects on other parts, and how system structures drive behavior. We applied these key concepts to thinking about institutional departments as complex systems throughout the workshop.

Habits of a Systems Thinker

The key principles and concepts of systems thinking have been encapsulated by the Waters Center for Systems Thinking (2020) in a series of 14 notecards called the "Habits of a Systems Thinker." Each card presents a key idea of systems thinking, such as "seeing the larger picture," "system structure determines system behavior," and "mental models" (i.e., implicit assumptions that drive behavior). We provided each team with a set of these cards (and each participant with a one-page version) for reference throughout the workshop. The participants could refer to the cards to identify habits they already practiced and those habits that needed further cultivation. Each team took the cards to share with their home departments following the workshop. The one-page version of the "Habits of a Systems Thinker" is available for online access and use (Waters Center for Systems Thinking, 2020; https://thinkingtoolsstudio.waterscenterst.org/cards).

Team Time

The workshop agenda (see Appendix A) was crafted to maximize time for teams to work together (e.g., reflecting on their departments as systems, identifying potential levers for change,

developing change strategies). Feedback from participants consistently revealed the value of time to work together, and we increased the amount of team time with each successive iteration of the workshop. Consequently, we recommend keeping presentations by workshop facilitators to a minimum in order to provide teams with the maximum time for working together.

Iceberg Metaphor

The iceberg is a familiar metaphor among systems thinking practitioners, linking several of the Habits of Systems Thinking in a diagnostic tool that is used to deepen understanding of a complex challenge. By "lowering the waterline" to expose "deeper" aspects of a challenge (Sweeney, 2001), we can inquire about patterns of behavior, system structures, and mental models so as to discern a particularly advantageous area on which to focus change efforts (see Fig. 1 for an example). We invited teams to use the iceberg metaphor to gain insights for transforming their systems by asking: If we change our thinking (mental models), what new structures might we create that will generate desirable patterns of behavior?

Community Building/Speed Networking

Participants in the first workshop suggested we include more opportunities to meet and learn from other participants. In response, we added a speed networking activity on the first night of all subsequent workshops. Each participant presented a two-minute "elevator speech," including the participant's goals for attending the workshop, to a group of seven other participants. Everyone then rotated to a new group of eight and the exercise was repeated for a total of three rotations, with each participant meeting about 20 others over the course of 45 minutes. Participants reported that they valued learning about the other attendees, their institutions, and their goals for the workshop.

Speed networking could be implemented during a video conference by using pre-assigned breakout rooms. Alternatively, online discussion boards or productivity software (such as Padlet [padlet.com]) could provide a format for each participant to present their "elevator speech" and allow for responses from other participants.

Dynamic Governance

The PULSE organization uses dynamic governance (DG), also known as sociocracy, to facilitate group decision-making both online and in person. Sociocracy uses "consent and collaboration as a foundation for decision-making and communications" (Buck & Villines, 2007), as distinct from the more typical majority vote process. Because DG requires consent, though not necessarily enthusiasm, from all participants, and sets time frames for revisiting all decisions, skeptics frequently allow a decision to be tested rather than standing in opposition. After some workshop participants expressed frustration that their departments had difficulty bringing policy discussions to a decision, we added a workshop module introducing the concepts of DG. We included information on how an individual can introduce aspects of DG to their department (Villines, 2019). Subsequently, several participants reported that these tools enabled them to overcome longstanding obstacles to agreement in their departments. For example, one department that had found itself mired in endless discussion of several policy decisions was able to agree to test proposals for two years, rather than continuing to debate the merits of different options. We note that DG is an especially effective facilitation strategy to use during video conferencing.

Vision Exercise

To prepare teams for developing an action plan for departmental transformation, we engaged the teams in a visioning exercise. This shared vision exercise is a recommended practice for sustaining change in STEM educational efforts (Fry, 2014; Henderson et al., 2010; Reinholz & Apkarian, 2018). The visual facilitator led the participants through a guided visualization activity (Gray, 2010) to imagine the ideal future for their department and its broad impact on the institution, the region, and beyond. Teams coalesced their individual ideas into a single poster (Cover Story Vision, 2019), creating a cover for a magazine or professional journal (Fig. 2). This exercise proved useful for team building and for teams to develop a shared bold vision for departmental transformation.

Figure 2
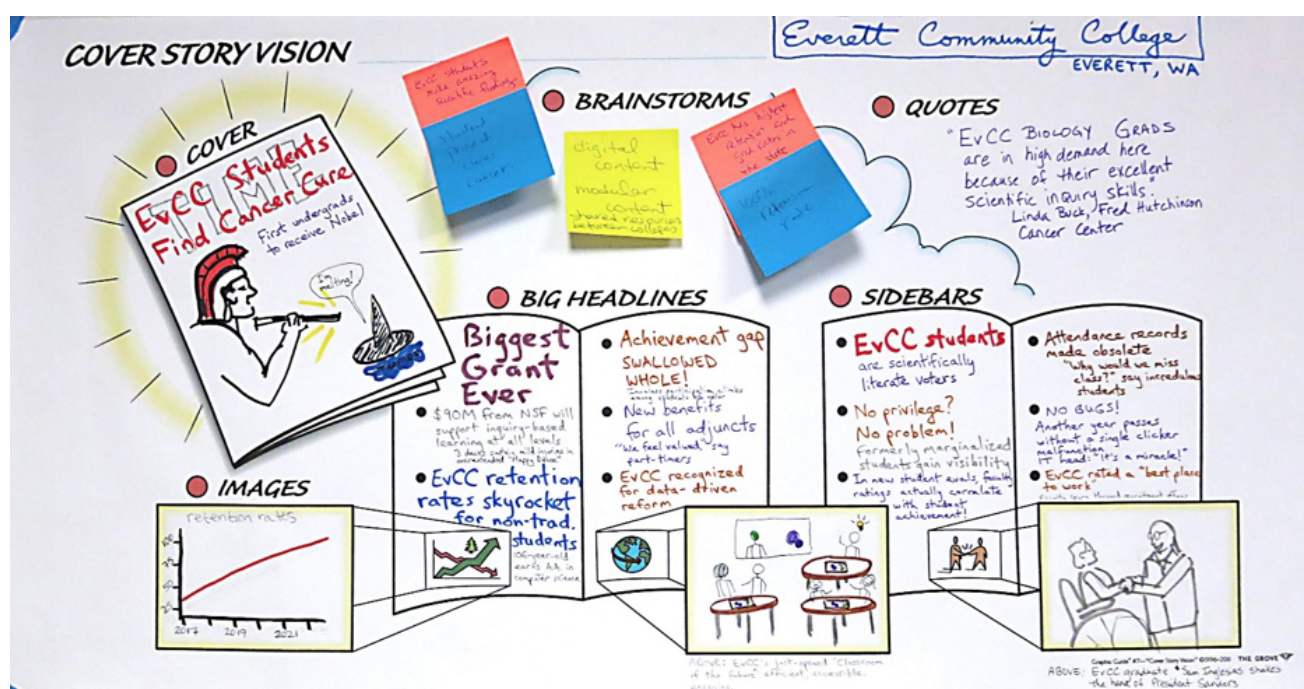
Example of the visioning exercise magazine cover (Cover Story Vision, 2019) produced by a team during a workshop.

Action Plan Poster

After completing the vision exercise, each team then addressed the principal outcome of the workshop—to agree upon a workable set of shorter- and longer-range goals and to develop an action plan to achieve those goals. Teams, with assistance from their coaches, reviewed the bold vision for their department, analyzed their systemic challenges to achieving the vision, and employed systems thinking tools to create an action plan for their departmental transformation. We provided a poster template (Fig. 3) to each team so they would have a clear, agreed-upon action plan. Using a template expedited the team planning process by focusing team discussions and improved intra- as well as inter-team communication. The template also allowed for efficient assessment of team action plans.

Figure 3

POSTER TITLE	
Team Members	
Problem & Goal What problem are you addressing? What is the main goal your team hopes to accomplish by NWBIO in May?	
STRATEGY/LEVERAGE What is your general strategy to reach your main goal? Will your strategy change or create structures, patterns, or paradigms?	
ACTIONS What specific actions will be taken, and by whom?	**ENGAGE ALLIES** Who else should be involved in your efforts? How can you engage them? Who are your allies (or who need to be your allies)?
STRENGTHS & RESOURCES What strengths do you possess or resources do you have available to you to support this work?	
EVALUATION How will your team know if you are successful?	

Template for team action plan poster.

The teams presented their action plans to each other during a poster session on the final day of the workshop. This session was designed as a "gallery walk" that provided a forum for participants to review the work of each team and to comment or make suggestions on that work. The posters also provided a convenient way for teams to share their work with colleagues upon return to their home institutions. We actively encouraged participants to display their posters in high-traffic areas in their departments and to share their posters with their institutional administrators.

For virtual workshops, teams could create action plan posters in an online format using a shared document or productivity software. Each team could then present their work to the other participants in an online group session. Action plan "posters" could also be presented through a discussion board, or shared online whiteboard, allowing for an asynchronous comment period.

Wall Walk

By the end of the workshop, several posters that encapsulated the events of the workshop—generated by the visual facilitator—were displayed on the walls of the main workshop meeting room. We facilitated a brief "wall walk" activity near the end of the workshop, when participants walked around the room and reviewed the posters. This exercise allowed participants time to briefly review all the graphics and to reflect on their overall workshop experiences. In an online workshop format, a slide show of all visual products from the workshop could be used to provide this reflective time for participants.

Check-out

At the end of the workshop, the facilitator invited a check-out process (Kofman, 2018) designed to encourage a brief reflection on how the participants' perspectives shifted over the time of the workshop. Each participant was invited to complete this sentence, speaking to the whole group: "I arrived feeling [one or two words], and I'm leaving feeling [one or two words]." This activity served multiple purposes. It gave participants an opportunity for self-reflection, while also allowing the facilitation team to gain insights about participants' shifts in mindset related to the task of department-level change. Additionally, because participants' responses typically reflected a positive shift (i.e., "I arrived feeling *doubtful*, and I'm leaving feeling *hopeful*.") the activity created an encouraging atmosphere and provided a strong closing for the workshop. The repetition of hearing a check-out response from each participant created a sense of collective agreement that "something has happened here, change is happening, and we are all part of it." The check-out also serves to bring each voice into the room, physical or virtual, one last time.

Summary—Taking the Workshop Online

We have described a number of workshop activities that provide valuable in-person experiences for participants. While some of the workshop's features will not translate to a virtual format (e.g., socializing with other participants at meals or during breaks, the triangles exercise), most of the described activities can be offered in an online format that will enable participants to gain a similar workshop experience. For example, including teams from all types of institutions allows participants to see that they experience common challenges and to share ideas. Because a typical workweek for faculty members does not offer opportunities for contemplation of their department's long-term goals, providing extended team working time, with facilitation, away from the daily routine enables workshop participants to make rapid progress on planning how to address their challenges. Through the use of tools such as discussion boards, video conferencing with breakout room capabilities, and productivity software (such as Jamboard or Padlet), interactive workshop sessions can provide teams with the opportunity to develop their systems thinking facility and to design transformation strategies to enact in their departments and programs.

Post-Workshop Activities

In the months following the workshop, coaches checked in with participants on approximately a monthly basis to learn about the team's progress on its action plan and any obstacles encountered, and to provide assistance and advice for continuing progress. After the third year, we also offered periodic webinars on topics requested by participants, including developing curriculum maps (see Appendix A for an example) to identify strengths and weaknesses of existing curricula (Veltri et al., 2011; Wijngaards-de Meij & Merx, 2018), using concept inventories as assessment tools, and employing dynamic governance to facilitate departmental decision-making.

As a means to increase accountability to follow through on action plans, we hosted a one-day meeting that brought together representatives from each team to present posters on their post-workshop activities. This post-workshop meeting occurred in conjunction with the annual conference of the Northwest Biology Instructors' Organization (NWBIO) approximately seven months after the initial workshop. We reimbursed travel costs for one participant from each team to attend the PULSE post-workshop meeting and the NWBIO conference. A post-workshop online

conference, scheduled seven to eight months after the workshop, would provide a similar follow-up opportunity for teams to share their activities.

Prior to the meeting, we provided teams with an electronic poster template that included sections addressing vision and goal, actions, strengths and leverage points, barriers and challenges, resources and allies, unintended consequences, products and reflections, sustainability, and future goals (Fig. 4). We gathered and printed all posters at no cost to participants prior to the meeting. At the meeting, participants viewed all posters and provided feedback via sticky notes. Two facilitators then summarized major themes that emerged from the poster presentations and comments and led a group discussion about common challenges, resources, and change foci.

Figure 4

Template for the post-workshop posters. Participants presented their posters at a follow-up meeting about seven months after the workshop.

The post-workshop posters provided a rich source for discussion about strategies for departments to use to overcome barriers. Our meeting surveys confirmed that sharing this information proved useful for participants. In addition, external evaluators were subsequently able to use the posters to assess the outcomes of the teams' work and the effectiveness of our workshop approach.

Assessment

We used a variety of assessment strategies to evaluate our systems thinking-based workshop approach and to model the effective use of formative and summative assessment for enriching discussion and decision-making. Assessment instruments included pre- and post-workshop surveys as well as daily formative surveys during the workshop. In addition, an external evaluation team performed a multi-pronged assessment of the first three workshop cohorts to determine the longer-term effects of this approach.

Prior to the workshop, teams completed a survey and each team member completed one or more PULSE rubrics. We used the survey responses to inform our planning process and to strategically highlight areas that framed discussions at the beginning of the workshop. The team consensus rubric results were compiled in the PULSE rubric portal (PULSE Community, 2020). This repository allows the PULSE organization to characterize the state of life sciences departments and the outcomes of its work to effect change nationally in support of the *Vision and Change* recommendations.

During the workshop, participants completed short, formative surveys at the end of each day. The surveys provided real-time evaluation of workshop activities and participant perceptions. We tallied the responses and reviewed them during nightly facilitator debriefing sessions, modifying the plans for subsequent days of the workshop as necessary. For example, if participants reported the desire for additional time with their teams, we modified the schedule to include more time for team work.

Two to seven months after the workshop, each team member completed a follow-up survey that included one set of common questions that allowed for inter-workshop comparison, and another set of questions specific to each workshop cohort. Data from the pre- and post-workshop surveys were compiled and used to inform subsequent workshops and follow-up event planning and to facilitate the dissemination of workshop outcomes. Assessment indicated that the workshop itself was successful (92% of survey respondents found it useful or very useful). Successful elements of the workshop that were identified in surveys of the participants include: team action plans, the planning committee's continuous modification of the activities within and between workshops, use of the PULSE rubrics, and the accountability required of each team through participation in the follow-up meeting.

Most teams found the coaching at the workshop to be very useful (Offerdahl et al. 2019; Reiness et al. 2019; Stavrianeas et al. 2021); however, only 55% of respondent teams had substantial follow-up with their coaches post-workshop. Those teams who received more post-workshop coaching rated the follow-up support as more useful or very useful (67% and 33%, respectively). While some teams reported that they did not need/want their coaches' input after the workshop, other teams reported they would have welcomed a more hands-on approach from their coaches post-workshop. We anticipate that designing structured post-workshop contact, with specific tasks or goals for each team to report on at designated intervals, would provide continued benefits of coaching.

We engaged external evaluators from Education Development Center, Inc. (EDC) to assess the outcomes of the first three workshop cohorts. The EDC assessment team analyzed team action posters, surveyed individual participants, and conducted targeted interviews with a representative subset of teams to evaluate long-term (2–4 years) outcomes for workshop participants. A detailed analysis of assessment outcomes are discussed elsewhere (Offerdahl et al., 2019; Reiness et al., 2019; Stavrianeas et al., 2021). Briefly, EDC analysis of posters presented seven months after the October workshop showed that most of the institutions in the first three cohorts met at least some of their goals within that timeframe, with more than half (56%) meeting most/all of their goals (of those institutions that provided sufficient information for the evaluators to make a determination regarding the degree to which they met their goals) (Table 3).

Table 3

Goals achieved by participants within seven months of the NW PULSE workshop.

Rating	Number of Schools	Percentage of all Schools (n = 44)	Percentage of all Schools Coded (n = 32)
Met few of their goals	1	2%	3%
Met some of their goals	13	30%	41%
Met most/all of their goals	18	41%	56%
Unsure	12	27%	-
Source: NWBIO posters and spring post-survey data; n = 44; EDC Assessment			

In the follow-up survey, EDC evaluators asked respondents to report how much of a difference their involvement in the NW PULSE workshop had on their department. Two to four years after the workshop, the majority (54%) said that their participation had made at least a "Moderate difference," including 16% who said it had made a "Large difference" in their home departments (Fig. 5). There were no statistically significant differences in self-reported impact either by cohort or by institution type (i.e., R1, liberal arts, regional comprehensive, or community college).

Figure 5
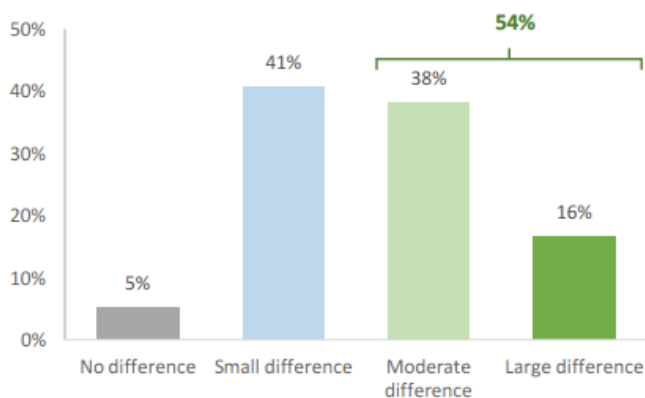
Impact of NW PULSE workshop participation on attendees' departments. More than half of the respondents (N = 79) reported that their involvement with NW PULSE had made at least a moderate difference in their departments. The survey asked: "It's been some time since you participated in NW PULSE. How much of a difference has your involvement in NW PULSE had in your department?" (Fitzhugh & Liston, 2018).

Reflections

Although student demographics in higher education are changing rapidly and new knowledge about how students learn is regularly generated (NASEM, 2018), undergraduate curricula and pedagogical practices have not yet evolved to fully reflect this new knowledge (Stains et al., 2018). Such curricular and pedagogical change in higher education is crucial if we are to serve the needs of current and future students and prepare them for their upcoming, diverse roles in society.

For effective change to take place, participants need to engage over an extended period (Baer et al., 2008; Henderson et al., 2010; Pundak & Rozner, 2008; Silverthorn et al., 2006; Walczyk et al., 2007) so that barriers can be overcome (Brownell & Tanner, 2012), effective change drivers can be identified (Shadle et al., 2017), and resources can be developed so that departments/institutions can exploit opportunities for improvement. Enacting such change at the department/program level is often a challenging process that requires negotiation among faculty stakeholders. The survey results from participants gathered two to four years after the NW PULSE workshops show that a crucial factor in making progress was to engage the majority of department members in a change initiative (Fig. 6). Thus, it is important to emphasize to the teams during the workshop that recruiting their colleagues to the change effort provides their best prospects for success and to discuss means for doing so.

Figure 6
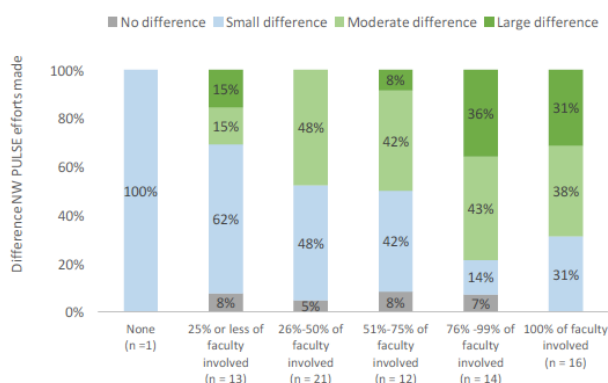
Faculty involvement correlates with effect of NW PULSE workshop participation. In general, the higher the percentage of department faculty involved in the work, the greater the NW PULSE impact reported. Results from two survey questions: 1) "About what proportion of the faculty in your department was involved with the effort to move your department towards the recommendations in the Vision and Change Report?", and 2) "It's been some time since you participated in NW PULSE. How much of a difference has your involvement in NW PULSE had in your department?" (Fitzhugh & Liston, 2018). N = 77.

Even when consensus for change is achieved, meaningful departmental change may take five to ten years (Kezar, 2009), which often involves continuing efforts to provide faculty development for both new and more established faculty members, as reflected in the following comments:

> "[We] informed other faculty in [the] department about Vision & Change recommendations—our faculty needed a boost to know that others were thinking about

institutional change and we were not alone in this effort. [We] provided professional development for faculty … primarily been attended by new faculty, and all of our new faculty over the past 5 years have participated. This is changing department culture." *(EDC Survey respondent)*

"One challenge has been that some of the older faculty are skeptical of what we can accomplish or what we can actually improve. That's a challenge. Mostly it's been addressed through discussions and encouragements and cajoling. Everybody wants to be the best teacher they can be and to provide the best learning environment they can provide, but there are different levels of enthusiasm for change, and I think that is inversely correlated with experience. It just takes time and energy to convince people who have been doing one thing for a long time to try different things. I think we've been somewhat successful. It's just there has been some resistance and some challenges to address over time." *(EDC Interviewee)*

Lengthy change processes without obvious progress can lead to discouragement or burnout. To address these challenges, we designed a process that provides faculty members with tools to enable them to lead their departments through curricular and pedagogical change more rapidly and effectively, producing change that is more likely to be sustained.

Given that departments/programs within higher education are complex systems with multiple interacting parts that can expedite or impede change (Manning, 2013; Meadows, 1999), our workshop strategy is based on systems thinking principles to support teams to facilitate meaningful, sustainable institutional change. Analysis of the effects of our systems thinking approach on departmental change is discussed elsewhere (Offerdahl et al., 2019; Reiness et al., 2019; Stavrianeas et al., 2021). Briefly, while respondents reported their involvement with NW PULSE made at least a moderate difference in their department (54%), participants who used systems thinking concepts routinely were more likely to report that their involvement made at least a moderate difference in their department (69%).

Conclusions

Overall, our workshop model using a systems thinking approach has been successful in empowering change agents to effect departmental transformation in the Pacific Northwest region and beyond. Our goal is to continue to educate stakeholders about the importance of curricular and pedagogical change in institutions of higher education and to provide tools to empower faculty members to facilitate that change.

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Appendix A: Sample Workshop Agenda

Day 1	
11:30– 12:00	Steering Committee pre–workshop meeting Participant check–in
12:00–1:00	Lunch Participants discuss Habits of a Systems Thinker cards (Waters Foundation, 2019)
1:30–2:00	Welcome, Brief history of PULSE and workshop objectives and agenda, pre–workshop survey results, introductions
2:00–2:40	Team members review *Vision and Change* rubrics with each other and with their coach
2:45–3:15	Triangle activity to demonstrate complex dynamic systems
3:15–4:15	Systems thinking including theory and activities, review of habits cards, iceberg metaphor (Sweeney, 2001)
4:15–4:30	Refresh and connect
4:30–5:45	Team time – Use a systems thinking perspective (habits of a systems thinker cards, and the iceberg metaphor) for deeper analysis, see whether teams can develop shared understanding about systemic causes, effects and interconnections
5:45–6:00	Recap and preview of next activities Daily assessment
6:00– 7:30	Reception and dinner
7:30–8:30	NW PULSE Community Building – Value of networking. Speed networking
8:30–8:35	One–word checkout
8:45 on	Teams continue as preferred Facilitators debrief and modify for Day 2
Day 2	
7:30–8:10	Breakfast
8:15–8:30	Welcome, overview of today's agenda, introduce Dr. Ann Austin (Professor of Higher, Adult, and Lifelong Education, Michigan State University)

8:30–10:00	Ann Austin: Taking a Systems Approach to Change in Undergraduate Science Education Presentation interspersed with team conversation
10:15–10:30	Group conversation: insights from Ann Austin's presentation
10:40–12:00	Vision exercise: Your department in five years – magazine cover
12:00–12:45	Lunch
1:00–4:00	Team Time: Putting it all together in a poster. Teams refine their vision, analyze systemic challenges, and use tools (e.g., iceberg model) to create an action plan for next steps.
4:00–4:30	Reflection – harvest conversation (1–2–4–all)
4:30–5:00	Encouragement and more tools – e.g., Dynamic governance, anecdotes
5:00–5:15	Recap of Day 2 and Preview of Day 3 Daily assessment
5:15–6:00	Free time
6:00–7:00	Dinner
7:00–8:00	Team time for posters as needed
8:05 on	Facilitators debrief and modify for Day 3
Day 3	
7:30–8:15	Breakfast Reminder about turning in rubric scores, distribute workshop evaluation scores
8:15–8:30	Put up posters
8:30–10:45	Poster presentations and poster walk – feedback on posters via sticky notes
10:45–11:00	Group photo
11:00–11:30	Resources – e.g., PULSE website, community of practice
11:30–12:15	Closing plenary session – preparing for NWBIO, walk the wall (review graphics), final reality check, reminder for evaluations, final one–word check out, thank you and good–byes

Appendix B: Curriculum Map Example

I=Introduced D=Developed & Practiced w/Feedback M=Demonstrated at the Mastery Level	B=Biochemistry GCB=Genetics and Cell Biology Mi=Microbiology

Course Numbers (MBioS)

	413	414	454	465	495	498	499
Degree Requirement	B	B	B	B		B	B
	GCB		GCB		B	GCB	GCB
Degree Elective	Mi		Mi		GCB Mi	Mi	Mi
Objectives							
Competitive for future goals (a)	D	D	M	D	M	M	M
Identify modern knowledge underlying B, GCB, M (A)	M	M	M	M		D	D
Ethics of scientific publication and research conduct (B)			D			D	D
Perform Basic Laboratory Skills (C)			M			D	D
Design, Perform, Quant./Qual. Evaluate Lab Expts. (D)			M			D	D
Locate, Retrieve, Evalute Scientific Information (E)			D			D	D
Prepare Oral and/or Written Reports in Standard Formats (F)			M			D	
Molecular Biosciences is Rewarding and Relevant (G)	M	M	M	M	D	D	D
Appreciate Ethical Implications of Science in Society (H)					M		

413	General Biochemistry I
414	General Biochemistry II
454	Biochemistry Laboratory
465	Physical Biochemistry
495	Internship
498	Graded Research Credits
499	Ungraded Research Credits