Science Communication across Disciplines: Reflecting on STEM Identity Building through Notation in Science Communication ePortfolios[1]

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Abstract: The Notation in Science Communication (NSC) provides students an opportunity to develop their abilities to effectively communicate technical information to varied audiences using multiple genres and modes. A total of 115 students have earned the NSC as of May 2023. Currently there are just over 100 students in the program, with between 40–50 new students admitted each year. The NSC is similar to a minor that culminates with the development of an ePortfolio capstone. In this article, we focus on the process of creating an NSC ePortfolio and on the scaffolding practices that we have integrated into our pedagogy. We analyze 44 student ePortfolios, feedback from student alumni, and an NSC student conference presentation. Three themes emerge: a) student ePortfolios articulate an increased understanding of multiple identities, and students explore how these identities make them more effective science communicators; b) students demonstrate evidence of growth and learning about science communication; and finally, c) they share their capacity for using science communication to be engaged citizens in their local and global communities. We argue that students graduate from our program with both a deeper understanding of the importance of science communication in responding to the pressing issues facing our world today, and also with a fundamental recognition of their place in the world as effective science communicators.

In 2015, we held our first conferral ceremony for students receiving a Notation in Science Communication for their work as part of the Notation in Science Communication (NSC) program at Stanford University. A multi-course mini-minor, the NSC offers our STEM students the opportunity to complement their disciplinary work in the sciences and social sciences with focused attention on communicating effectively across audiences and genres through coursework and a capstone ePortfolio project. At that very first ceremony, we held a gallery showcase of portfolios, and each student stood next to a large display screen, giving short tours of their work to the attendees and putting into practice many of the communication skills they had been developing through their NSC work. The texts they shared as part of their portfolio spanned a range of media (from academic essays to posters, presentation recordings, and even co-curricular examples of science communication drawn from their work outside the classroom) and demonstrated their integrative approach to their understanding of their growth as science communicators, one that pushed beyond the disciplinary

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boundaries of their major. However, some of the most moving aspects of the ceremony were their reflections; the stories each student told were as much about their identity and growth as communicators as the artifacts their portfolios contained.

Over the years, we have held many more conferral ceremonies, each marked by this culminating display—and celebration—of student work. In the process, we have confirmed the foundational premise that inspired our curricular design: creating the capstone ePortfolio provides the culminating learning moment for students, through which they can move from understanding their undergraduate experience as a sequence of requirements and electives to a more holistic appreciation of their education. Many have noted this important, integrative feature of ePortfolios (Morreale et al., 2017; Peet et al., 2011; Schrand et al. 2018; Watson et al., 2016; Yancey 2019). However, most situate their discussions of ePortfolios within the realm of general education or humanities programs. Yet, this holistic understanding is particularly important for STEM students who, as Theresa Conefrey and Davida Smyth note, often experience their undergraduate curriculum as a fragmented series of discrete courses in terms of acquired knowledge and skill sets (2020).

In fact, the ePortfolio approach is even more important for students interested in science communication, like those in our NSC program. Brian Trench and Massiamiano Bucchi (2010) describe science communication as a "recognized field of study in which there are people active who come from very many different backgrounds," but not as an established academic discipline (p. 4). Few institutions have dedicated science communication programs or departments. Typically, STEM students practice science communication, if at all, through a variety of Writing Across the Curriculum or Writing in the Disciplines (WAC/WID) programs (Thaiss & Porter, 2010), and particularly through writing intensive course assignments within their disciplinary coursework (Finkenstaedt-Quinn et al., 2021, Grzyb et al., 2018). However, science communication practices within disciplines can be highly specialized and not applicable across disciplines or for communicating with the general public (Schummer, 2008).

Therefore, the NSC ePortfolio not only provides an opportunity for students to integrate their growing disciplinary expertise in areas like human biology, earth systems, and engineering; it also helps students cultivate their identities as science communicators. Additionally, the ePortfolio provides a space for students to explore how they might develop a sense of civic literacy (Conefrey & Smyth, 2020; Schrand et al., 2018), synthesizing connections between their education and their capacity to meaningfully address some of our most pressing social and environmental issues. Indeed, for some students, the artifacts they include in their ePortfolios showcase the ways these students have already been contributing solutions to such challenges.

In this article, we share the results of our analysis of the ePortfolios created by students in our Notation in Science Communication program. Although we had envisioned the ePortfolio as a site that was both retrospective (reflecting on past experiences) and forward-looking (useful for graduate school applications and job searches), what we didn't anticipate was the way in which it would create a unique moment for STEM students to gain a deeper understanding of their discipline, their place in it, and how sharing their knowledge in different ways would foster a kind of agency for them directly connected to their identities as effective and reflective science communicators.

We begin by situating the work students do within the framework of our scaffolded NSC portfolio curriculum, with special attention to innovation in how we use the affordances of a flexible ePortfolio platform and opportunities of a metaphor-based rhetorical approach to promote greater student agency and deeper engagement with reflection. We then share three key findings from our analysis: students use the capstone ePortfolio to develop and integrate personal and professional identities; to articulate their growth and development as science communicators and disciplinary experts; and

to increase their capacity and awareness of what it means to be an engaged citizen, that is, how they can make an impact on the world.

Program Overview: The Notation in Science Communication

At Stanford, students' undergraduate experience is informed by thorough and thoughtful attention to the importance of effective communication skills. All students, regardless of major, must complete three writing and communication course requirements to graduate: one in the first year, focused on writing, rhetoric, and research; a second-year requirement that adds attention to oral and multimedia communication; and a third course, focusing on writing in disciplinary contexts (see Fig 1A). The first two requirements are taught by the Program in Writing and Rhetoric (PWR), an independent writing program housed within the Office of the Vice Provost for Undergraduate Education.[2] The final writing in the major course (developed in alignment with a WID model) is overseen by a Writing and Rhetoric governance board, but administered and taught by individual university departments.

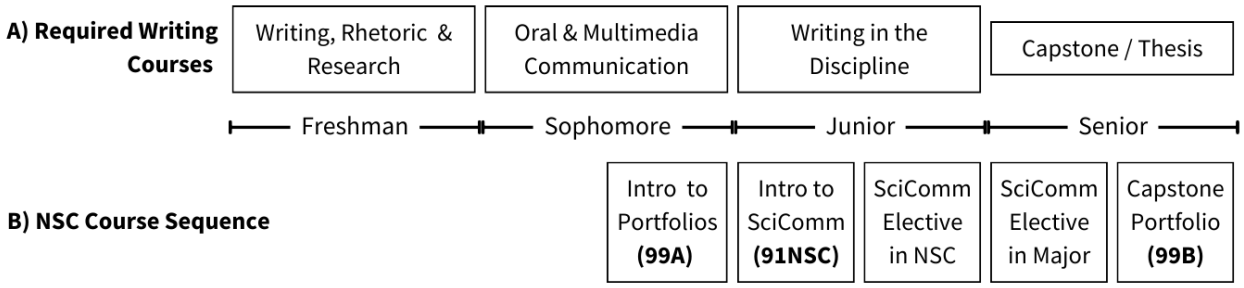

Figure 1: Coursework for the NSC adds an additional layer onto the writing requirement for NSC students[3]

In recent years, the number of STEM majors has risen dramatically at our university, and with this increase has come increased emphasis on helping students learn to communicate their science research effectively across a variety of audiences. In response, the Program in Writing and Rhetoric launched the NSC in 2013 to expand the opportunities for undergraduates to pursue their interest in science communication as a complement to their work in their majors. Housed in the Program in Writing and Rhetoric, the NSC program was designed to be similar to a minor or certificate program, taken in tandem with majors like Human Biology, Computer Science, or Mathematics. The NSC program moves the students through a sequence of courses, but with a low unit count to make it accessible to students in the School of Engineering and other STEM majors who were navigating unit-heavy course loads due to their major requirements. In total, students complete 13–15 additional units (approximately five additional courses) as part of the NSC, including one class with a science communication component taught by their major department; an introduction to science communication course and an additional science communication elective, both taught by the Program in Writing and Rhetoric; and two classes focused on preparing the capstone ePortfolio, also taught by PWR (see Figure 1B). These portfolio courses serve as bookends to the NSC student experience, ideally taken during the first quarter and last quarter of their participation in the program. Currently there are just over 100 students in the program, with between 40–50 new students admitted each year.

Students choose to apply to this competitive program early in their academic career for a variety of reasons. Many are interested in how to distill complex scientific and technical information and share it with a general, non-expert audience. In their applications to the NSC, students recognize the

growing importance of science communication in responding to the pressing health and environmental issues facing our world today. In fact, we've found interest in NSC has only grown in recent years as the impacts of climate change become more severe and reach a wider range of people, as the COVID-19 pandemic makes more visible the need for accurate and effective health communication, and as ethical questions are raised about the role of artificial intelligence and machine learning technologies in our society. Our students increasingly turn to the NSC to learn the tools needed to work on the front lines in responding to these intersecting crises.

NSC ePortfolios: Unpacking the Capstone Project

When we approached the task of designing our capstone project, we undertook a folio thinking (Penny Light, Chen, & Ittelson, 2011), writing as learning (Clark & Fischbach, 2008; Thaiss & Porter, 2010), and ePortfolio as curriculum approach (Yancey, 2019). The NSC ePortfolio is not just a container for student work; creating the ePortfolio is an integral part of student learning. For this reason, we focus less on any artifact itself and more on the process of reflecting on the growth the student experienced during the creation of the artifact and the ways in which the student is applying their learning as a science communicator.

As the culminating capstone project for the program, the NSC ePortfolio includes three main elements:

1. A cohesive and engaging cover letter that describes the student's identity, demonstrates their learning, and provides a framework for viewing the ePortfolio. The cover letter might introduce the author, identify discipline and interests, explain how they became interested in science communication, and integrate images and other visuals. This is a site of metacognition and the unifying element behind the portfolio.
2. Between six and twelve carefully curated examples of work, or artifacts, that provide evidence for learning. The artifacts represent a variety of genres and modes, from podcasts to essays, presentation recordings, information graphics, and research posters. They can be drawn from any curricular or co-curricular work done while at Stanford, so students might, for instance, showcase work they did as part of their summer research internship alongside an essay they wrote for a class in their major. We encourage students to include artifacts that may not be perfect, but which allow opportunities to reflect on their learning and growth.
3. Reflections that contextualize artifacts and expand on the overall message about learning presented in the cover letter. In written reflections accompanying each individual artifact, students explain why they chose to include that item; who the intended audience was; and how they grew as a science communicator from the process of creating it. Some students choose to include additional reflections on artifact groupings or on their future goals.

Additionally, we want to make sure that students pay attention to how they bring these three main elements together in their ePortfolios. We ask students to create a purposeful design with a clear site architecture and thoughtful visual rhetoric that supports their overall message about their identity and learning. To that end, we provide access to different design tools and resources. Most students build their ePortfolios using the online tool Digication, although students can petition to use other platforms as needed.

Completed ePortfolios are evaluated by a members of the NSC evaluation committee, a group of instructors and program directors who are equally divided between the Program in Writing and

Rhetoric and STEM programs and departments across campus, including the Human Biology program, the Earth Systems Program, Civil and Environmental Engineering, and the Jasper Ridge Biological Preserve. In this way, the NSC trades on the benefits of cross-disciplinary collaboration found in many WAC/WID programs.

Evaluation teams are assigned several portfolios and asked to rate the portfolio according to an NSC rubric (see Appendix) by evaluating six criteria: purpose–learning and growth, cover letter, additional reflections, artifact curation, design, and mechanics. Paired evaluators assess their assigned portfolios individually, then meet to discuss their assessment and make their final recommendations about whether the students have successfully met the criteria for receiving the NSC. In some cases, evaluators may suggest that students revise and resubmit their ePortfolios, providing feedback about areas for improvement. For those successfully meeting the criteria, evaluators confer a pass or even a pass with distinction if an ePortfolio demonstrates excellence in the evaluation categories. Students then receive a notation on their official Stanford transcript upon graduation, indicating that they completed advanced work in science communication during their undergraduate career. Final versions of the ePortfolios are submitted to Stanford's digital repository and, with permission, links are posted on our NSC website, contributing to our public gallery of student work.

As a whole, the process of creating the NSC ePortfolio has a tangible and long-lasting impact on students. Informally and anecdotally, through our annual gatherings, events, and alumni panel, our NSC alums have told us how they continue to use their ePortfolios after they graduate. They share them with prospective employers during the job interview process and with graduate school admissions committees, who use the ePortfolio as one way to assess science communication skills. Some NSC alums continue to add to their ePortfolio on their own. They appreciate that, as a "living portal" (Nguyen, 2013), the ePortfolio provides them space to archive and reflect on their ongoing work in science communication, even after concluding their formal work with NSC. They also continue to draw on the skills they developed in creating ePortfolios in post-Stanford contexts; because the ePortfolio process helps them develop their transferable communication skills, they report that they can more adeptly present their scientific and technical work to a variety of audiences in their current careers.

Scaffolding Folio Thinking and ePortfolio Preparation

Our carefully structured two-sequence portfolio preparation curriculum bridges the academic years and offers active-learning models for reflection and folio thinking, about which we have published previously (Stonaker et al., 2019). However, as Cathleen Morreale and colleagues (2017) have noted in their study of a pilot general education ePortfolio, key to growing a successful pedagogy that supports portfolios as a site of active learning and reflection is intentional pedagogical design and a willingness to iterate and innovate on that pedagogy.

In our case, over the last 10 years, we have focused on evolving our original curricula, layering in additional scaffolding to help cultivate a productive learning experience, one that provides students with templates for portfolio building but also challenges them to innovate on those templates in line with their individual academic experiences. In this section, we detail three curricular approaches we've implemented to scaffold deep student engagement with the process and possibilities of portfolio building. These include: (a) guided curation of artifacts and reflections, (b) storytelling exercises as a way to develop their cover letters, and (c) organizational metaphors to promote deeper reflection and meaning-making as part of the portfolio construction process. Each of these approaches directly supports the outcomes of identity-construction, reflection on growth, and awareness of engaged citizenship that we explore in our final section of this article.

Guided Curation of Artifacts

As noted above, NSC students are required to take two courses on portfolio preparation—one shortly after their admittance to the program (an introductory course, number 99A) and one in their final academic quarter with NSC (capstone course, number 99B)—to support them in developing a robust and reflective ePortfolio. Conceived of as a sequence, even though students may take them more than a year apart, these courses help students navigate between general principles of artifact collection, curation, and reflection (99A) and the practical logistics of constructing their own capstone NSC portfolio (99B). This two-course approach is a hallmark of the NSC. It provides students with the opportunity to extend their folio thinking practice across the undergraduate experience rather than being relegated solely to their final academic term.

Our first step in this sequence (completed as part of the introductory 99A course) relies on student creation of a templated mini-ePortfolio. This process asks them to enact similar moves as those they will rely on when constructing their capstone in their senior year, but with a simplified template to more explicitly guide artifact curation. Through a weekly scaffolded process, the course assists students in designing this mini-ePortfolio through a series of engaging and interactive activities, including concept mapping, small group discussions, and creative exercises to help students reflect on their multiple identities and the ways those identities inform their own science communication journeys. Perhaps the most useful component of this process is the guided practice of developing the mini-ePortfolio itself, drawing on a set of standardized pages and practices aligned with learning objectives related to folio-thinking and reflection.

The first two pages required for the introductory 99A mini-ePortfolio help students to develop focused strategies for effective curation and reflection. In terms of the genre or mode, students are given a lot of flexibility in terms of what can be counted as an artifact for this assignment, just as they will be when developing their final capstone ePortfolio in their senior year. While many of them choose work they have completed in their courses, we also encourage them to draw from their extracurricular activities, internships, and research projects taken up outside of class; they may include artifacts from a variety of genres, including documents, slides, posters, podcasts, StoryMaps, and presentation recordings. We find, similar to Schrand et al. (2018), that encouraging students to draw from work across disciplinary and curricular contexts deepens student reflection and metacognition.

That said, our deliberate guidelines on artifact selection require that they include just two artifacts in their mini-ePortfolios: an "Application of Learning" artifact and a "Room for Growth" artifact. The "Application of Learning" artifact should be one where the student demonstrates specifically how they incorporated effective strategies of science communication in creating that particular text. "The Room for Growth" artifact, on the other hand, is one that did not turn out exactly how they had hoped. This artifact is crucial because it moves students away from conceiving of all artifacts as "perfect" or "finished," and instead recognizes that being able to articulate learning and growth as a science communicator is just as valuable, if not more so, than the artifact itself.

We explicitly ask students to pair curation and reflection in the introductory 99A course through a set of clear writing prompts delivered in class. For each artifact, we first ask students to introduce the artifact to their audience of classmates and instructors. (Why did you create this artifact? What is the genre and/or mode? Who was the intended audience?) Then we ask them to reflect on the rhetorical choices they made in this artifact. (How effectively does the artifact meet the genre standard? How well did you adapt to your intended audience? What other rhetorical choices did you make?) We remind them that they do not have to cover every choice that they made but they should be specific. Finally, we ask them to reflect on their growth and the application of what they learned. (If you could redo the artifact, what would they do differently? What lessons do you take from this

artifact that you can apply to their other science communication work?) These scripted reflective moves help students learn to layer metacognitive processes into the practice of portfolio-building.

Students incorporate three additional pages into their 99A mini-portfolio. The first is a brief "About Me" page, which asks them to articulate their identity in relation to their discipline and science communication; this anticipates the more extensive reflective cover letter they will compose as part of their capstone ePortfolio. In their "About this Portfolio" page, we ask them to share their design choices, including color palettes, fonts, and sources of images and visuals. This process helps them to see that their choices are not arbitrary and that the design of the portfolio is as important as the content they are including. Their final contribution to the mini-ePortfolio is a "Future Directions" page, where they are asked to reflect on what they would like to accomplish during the rest of their time in the NSC. This step is in keeping with Nguyen's recommendation to "encourage reflections of past, present, and future in ePortfolio programs" (2013, p.146), and it lays the groundwork for the future-facing components of their reflections in their capstone, where they will discuss the forward transfer of their science communication skills post-graduation.

In this way, we have deliberately scaffolded the introductory 99A curriculum to align with Kathleen Blake Yancey's idea of ePortfolio makingness (2019). In this approach, the ePortfolio "not only host[s] learning" but creating the ePortfolio is "an integral part of that learning" (2019, p. 3). By adapting this approach to our own curricular context, we have come to recognize its benefits; it invites students understand the process of ePortfolio creation as a journey of curation, selection, and reflection, guided by the implicit story they want to tell about their own intellectual journey as a science communicator.

Storying the Cover Letter

As noted earlier, one of the most important parts of the NSC ePortfolio is a cohesive and engaging cover letter that describes the student's identity, demonstrates their learning, and provides a framework for viewing the ePortfolio. While we begin the process in 99A through the development of an "About Me" page, we devote a considerable amount of time to scaffolding the process for students in the capstone course, 99B. Our "Finding Your Story" activity helps students to develop a framework for the story they will tell using sticky notes on a whiteboard (physical or digital).

We start by asking students to add the name of each of their artifacts on a separate sticky note or small piece of paper, using different colors to represent different types of artifacts. After they have spread all of their artifact notes out on their work surface or digital whiteboard, we ask them to choose a storytelling prompt and add it to the top of their work surface. We then direct them to arrange 10 to 12 artifacts to tell the story described in one of the prompts (detailed below) and to annotate the arrangement to show relationships, flow, etc. We ask them to consider: What story does this arrangement tell about your science communication identity and/or learning?

The storytelling prompts, which are taken from archetypes, are adapted from *The Science Writers' Handbook*. While editor Michelle Nijhuis (Writers of SciLance, 2013) promotes the use of these prompts when developing a story, she also cautions that "sticking too closely to an archetype creates a cliche, of course, and can distort the facts" (p. 77). In class, we remind students that they should use these prompts for inspiration while being aware of their constraints.

The first prompt is "Chronological**."** This is the most basic story. Students can arrange their artifacts from oldest to newest or newest to oldest with equal numbers of artifacts from each year, or randomly choose them from across their time at Stanford. The second prompt, "Rags to Riches," asks students to arrange their artifacts to show how their work has changed as they grew from a lowly freshman to a wise senior. The third prompt, "Voyage and Return" is a circular story arc. Students

can arrange their artifacts to show how they had to leave home and then return before they could recognize its true worth. Prompt four, "Overcoming the Monster**,"** shows how the student rose above a challenge—a complex course, a tough extra-curricular project, a thought-provoking concept, et cetera—to reach their goals. Prompt five, "Rebirth**,"** highlights a radical transformation. Prompt six, "The Quest," asks students to arrange their artifacts as stepping stones towards an ultimate goal. Finally, the last prompt, "Comedy**,"** shows how the student triumphed over confusion and adversity to successfully complete the NSC. We encourage students to use these as building blocks for their own stories rather than mimicking the exact blueprint.

We encourage students to test out multiple storytelling prompts. Similar to the life stories reflection activity that Susan Kahn (2019) describes for her English senior capstone class, we find that giving students the opportunity to reflect on alternative narratives, along with careful instructor feedback and peer review, deepens their metacognition and helps them think more creatively about their ePortfolio, and their identity, as a whole. Students typically end up incorporating different elements of several of the prompts which serves as a useful reminder that their journeys are complex and nonlinear, not bound by singular archetypes.

Ultimately, this activity is an anchor of our capstone curriculum. By mapping out a journey that they can articulate in their ePortfolio cover letter, students can both better situate themselves within their NSC story and battle the curricular fragmentation they face within their STEM majors. As instructors, we appreciate how these kinds of storytelling templates serve as launching points for students to add complexity and creativity into their ePortfolios.

Organizing the ePortfolio through Metaphor

By the time students take 99B, the final capstone course, they are seniors who come to class with more experiences and many have a clearer idea of who they are and where they want to go. In order to best meet them where they are, we now incorporate a scaffolded intervention into the ePortfolio construction: metaphoric organization.

The use of the organizational metaphor reflects both refinement of our learning objectives over time as well as a response to the affordances of our digital platforms. When the program first began, we used an ePortfolio platform that allowed students to list out their artifacts but which did not allow for grouping of artifacts (Cohn et al., 2021). Thus the de-facto linear structure provided a ready-made rationale and organizational schema for the artifacts.

However, even at this point, some students pushed back against the linear format, which they felt to be somewhat limiting to what they wanted to communicate to their reader. They began to group the artifacts more conceptually, using metaphor to contextualize the new artifact groupings. In this section, we will use examples from student ePortfolios to show how these organizational metaphors evolved; more details on our method for collecting and analyzing student voices can be found in the next section.

An early metaphor we saw emerge was that of the scientific paper, with one student grouping artifacts under placeholder headings such as "Abstract" and "Methods," which the student described as "a choice that illustrates my identity as a science communicator" (Connolly, 2015). This organizational choice created a site for higher level thinking about the relationship between the items.

A shift toward a more sophisticated approach to artifact arrangement corresponded to a change in the affordances of our digital platform. After institutional pressures led to a switch in ePortfolio platform (to Digication), students had a new ability to create more complex site designs, including hierarchical pages and groups of artifacts, especially as the Digication platform itself began to add

new features. As students began more complex groupings of artifacts, many included additional reflections on how they had arranged their artifacts, and we began to develop scaffolded opportunities for students to think intentionally about their artifact groupings and site design in the 99B capstone portfolio course (Cohn et al., 2021). As others have, we found the opportunity for students to individualize the ePortfolio structure to be a key learning moment that opens up possibilities for reflection and growth (Morreale et al., 2017). Rather than simply asking them to write "About Me" and "About my Portfolio," as we had in 99A, we encouraged students to be intentional in their design in a way that made a cohesive argument about both their work and their own identity that was reflected in the structure of the ePortfolio itself.

We have found that an organizational metaphor was the most effective means by which students might provide a rationale for the structure of their ePortfolio. We offered opportunities for group brainstorming, discussed models in class, and led a series of activities that included asking students to write a one sentence story about their identities as science communicators and develop a visual metaphor to communicate their story in images and illustrations. We quickly came to recognize the additional benefits of this methodology beyond simply greater creativity in organization; as past studies have argued, metaphorical conceptualization in ePortfolios help students "build connections and engage in high-order processes of representations" (Morreale et al., 2017). In other words, by presenting and synthesizing their work across the NSC within the context of an extended analogy, students were able to make the connections necessary to integrate their learning and demonstrate their identity, knowledge, growth, and/or impact more holistically rather than in relation only to particular classes or artifacts. The metaphor structure helped the ePortfolio become a site of integrated reflection.

NSC students are exceptionally creative with categorizing their artifacts. Early NSC ePortfolios demonstrated a clear focus on rhetoric as the organizing lens for the arrangement, with students often arranging their pages by audience type (expert audience, lay audience, general audience) or by context (classroom work, research, extra-curricular); or even by purpose (for example, Downie's grouping of artifacts into the categories labeled as "communicating research methods," "communicating uncertainty," and "communicating changes"). Building from these models, later students began choosing metaphors that align with their future careers or that reflect their diverse experiences at Stanford. As students became more innovative with this organizational schema, they increasingly drew on a range of different types of metaphors for their ePortfolios.

Some of the students, for instance, relied on abstract analogies to organize their artifacts, such as a student who drew on the analogy of food groups (quickly digestible communication artifacts as fruits; those that take slightly more processing time as whole grains; those for a specialist audience as "high-fiber veggies"; Blanco, 2022) or a holistic anatomical system (head/conceptual, heart/emotional, and hand/practical; Drake, 2021).

Several students have drawn on concepts or frameworks from their discipline as the basis for their organizational metaphor. For instance, one civil and structural engineering student used the metaphor of a house blueprint to layer their work "like stories in a building, from foundational details to top-floor concepts," moving from a foundation of "how to do engineering," to the ground floor artifacts that capture "the immediate impacts of engineering on the human experience," and final the top floor, which contains "abstract questions about the social and cultural meaning of engineering itself" (Thompson, 2018). Another student, a geologist, created lenses for each artifact category, defining lenses "in the context of this ePortfolio as a set of tools—skills and knowledge—that enables the detection and dissection of geologic problems and the storytelling that follows." In organizing in this way, the student was able to "cover much of my meaningful growth as a science communicator" (Collar, 2018).

Perhaps some of the most innovative approaches to this rhetorical method are those that integrate the author's personal identity into their organizational structure. For instance, one student tied together their identity as a West African with their interest in immunology and infectious disease by using a metaphor of defending one's home from invaders. As the student stated in their cover letter:

> Using this metaphor, the home I am defending is my home as a west African; artifacts that are related to my identity as a west African can be found in the section "The Castle". Artifacts that are related to pathogens can be found in the section titled "The Invaders". The section titled "The Defense" includes artifacts that focus on the immune system. In the section "Beyond the Victory", I include artifacts that go beyond the scope of the other sections previously mentioned. All together, my artifacts, artifact reflections and organization hope to tell a story of who I am as a west African scientist and science communicator, who I want to be as a science communicator in the future, as well as the lessons I am learning on my journey towards my future as a science communicator. (Peterson, 2020; capitalization and punctuation as in original)

This organizing metaphor even contributed a visual color scheme to the portfolio, as the student chose colors that were significant within their West African culture. In using metaphoric organization in this way, this student—and others—was drawing on their training as a science communicator, recognizing the usefulness of analogies in communicating complex ideas to their audience (Gerecke, 2019). Through these observations, we confirmed Munday et al.'s (2017) assertion that visual metaphors can operate as a "complementary strategy to the suite of strategies academic teachers are currently using for developing a student's sense of self" (p. 62), and therefore affirms metaphoric thinking as a tool for ePortfolio practitioners that should be deliberately scaffolded into portfolio curricula. We will continue this discussion of metaphor and identity in the next section.

Methods and Analysis of NSC ePortfolios: Student Work and Learning Outcomes

In the first part of this paper we focused on the process of creating an NSC ePortfolio and on the scaffolding practices that we have integrated into our pedagogy. In the second part, we turn to a more focused case study of the NSC program, analyzing several components, including student ePortfolios, feedback from student alumni, and an NSC student conference presentation.

Our primary qualitative analysis was based on 44 student ePortfolios that have been completed over the past ten years. Our selection was based on ePortfolios that were publicly available and which we have written permission from students to use.[4] We read the ePortfolios from our positionality as ePortfolio evaluators, NSC advisors, and PWR program directors who have been involved with the NSC since its inception.

We also analyzed transcripts from our inaugural NSC alumni panel, which the NSC hosted over Zoom as an opportunity for current students to see how NSC alums were using the notation in their lives after graduation. In addition, we analyzed prepared remarks from an NSC student panel presentation at a Stanford symposium focused on teaching. During this panel, students shared the process of creating their portfolios and the lessons they learned from their time in the NSC.

Our analysis was informed by grounded theory and a process that involved collaborative reading for emergent themes. Three common thematic elements emerged in our reading and informed our subsequent systematic coding of the student materials: students articulated an increased understanding of their multiple identities and explored how these identities made them more effective science communicators; students demonstrated evidence of growth and learning about

science communication; and finally, students shared their capacity for using science communication to be engaged citizens in their local and global communities.

Developing and Integrating Personal and Professional Identities into the NSC Portfolio

In her work on identity construction in an English capstone seminar, Susan Kahn (2019) highlights identity development as an implicit feature of much undergraduate curricula; she argues that this process is critical in students actualizing their potential for success at the college level while also equipping them to "assume identities as emerging citizens and professionals prepared to learn independently, work across cultural differences, and contribute to their communities" (p. 90). In particular, she notes how portfolios can function as fertile "sites of self-authorship, self-exploration, self-presentation, and empowerment" for students, allowing them space to do purposeful work (p. 89). Our work with NSC students is consistent with Kahn's findings. During the portfolio process, students have embraced the power of narrative and reflection as drivers behind identity construction, using their own sense of self as a driver behind much of their learning as a science communicator.

In their NSC capstone, many students focused on their professional identities as an anchor for their portfolio construction. Some research has suggested the efficacy of using ePortfolios to help students construct a professional brand or discipline-specific narrative for themselves (Graves & Epstein, 2011), and some NSC students certainly did construct their ePortfolios with the goal of showcasing accomplishments to future employers or graduate admissions committees. However, we also found that many of our students took a more sophisticated approach. For example, one geology major used her guiding metaphor to reflect her professional identity, organizing her portfolio around the methods she used in her research. Each page of the portfolio focused on a different method, and the student used visual imagery to reinforce the metaphor. For example, on the page describing the section on numerical modeling, she stated:

> Unlike laboratory analyses and field observations, numerical modeling is not based upon primary observations of natural materials. Instead physical equations, like those pictured right, are used to generate "data" like the upwelling plume pictured left. Physical models are used to make predictions that can be integrated with field or laboratory data. (Birnbaum, 2018)

Concurrent with building her ePortfolio, this student was applying to geology PhD programs. In organizing her portfolio in this way, she was able to demonstrate her understanding of geology research fundamentals and show that she was a member of the community of geology researchers. We observed similar practices in many of the students who used disciplinary-based metaphors. In these cases, students used the language and structure of the ePortfolio to signal belonging within their academic field.

With our focused work on reflection and storytelling in the preparation courses, it is not surprising to find that many NSC students alternately framed their work as STEM students and as science communicators with reference to their personal identities. In many cases, our students shared in their cover letters how they found exigence and motivation for their work in their background or individual passions. For instance, one student wrote about how her upbringing influenced her academic trajectory and she turned to science communication to help her reconcile tensions in her personal and academic life:

> I grew up on a ranch in rural Oregon surrounded by cattle ranchers who deeply cared about the world around them, but weren't always informed on environmental science. Coming to Stanford, the environmental science courses I was taking would mention large-scale agricultural practices and their impact on the environment, but often wouldn't mention the more regenerative or grass-fed options that I grew up around. Throughout my first two years at Stanford, I was still figuring out how to reconcile my upbringing in rural Oregon, knowing that my county wouldn't survive without the cattle industry, and my desire to help build a more sustainable world. Science communication became the place where I could bring these two seemingly different views together. (Ferre, 2021)

This student's maneuvers between competing identities and clearly replicates the process Cuevas-Garcia (2021) described in his study of how academics navigate identity through biography: "Through use of biographical narrative, individuals can negotiate their identities as specific types of people and as members of particular communities" (p. 248). He discussed this process in reference to scholars negotiating between a broad academic identity and one defined by a specific discipline; clearly, our students were engaged in a more expansive project, as the ePortfolio process helped them to align their personal selves and interests with their growing identification with a particular academic field.

To return to the student example above, one comment was particularly notable: "Science communication became a place where I could bring these two seemingly different views together." This was a common theme that emerged in the NSC ePortfolio cover letter: the way in which students used the cover letter to grapple with disparate identities, while ultimately deepening their understanding of how each enhances and amplifies the other. This was particularly the case when students reflected on their roles as both a writer/communicator and a scientist. For example, one student wrote in her cover letter:

> I am a scientist and I am also, now, a writer. These two identities of mine have blended and enhanced each other to make me into a science communicator. I've gained freedom in this title to explore my passions and new ways of sharing them with others. However, I've also gained a new responsibility to share the stories and experiences of those who can't. My best work so far as a science communicator has focused on doing just that for vulnerable populations, such as female soldiers, so that my writing will hopefully create positive change for the issues they face. This is who I want to be: a science communicator with passion and skill that can make positive impacts for those in the world who need it. (Numazu, 2020)

Another student similarly used the cover letter of her ePortfolio to map out her journey of melding the two identities as part of understanding her larger life trajectory:

> My process of moving away from a binary, divided conception of myself as holding two conflicting identities of 'scientist' and 'communicator' was not linear, and is an ongoing process today… As I transition from my undergraduate degree into my M.A. in Environmental Communication, I am more aware than ever of how my life's trajectory is not (and should not be) linear or easy to encapsulate in neat generalizations. I can embrace both the Sierra who wanted to study sea otter toxoplasmosis and the Sierra who wanted to communicate and tell stories about the sea otters existing in their ecosystem, not as amenable neighbors, but as a dynamic duo. Partners in crime. I will continue to be a woman of both scientific and creative minds, and I relish the potential for exercising both of them together for the rest of my time at Stanford and beyond. (Garcia, 2018)

Through grappling with the complexity of her identities, she gave herself not only a framework for organizing her portfolio but also for moving out into her professional career.

As we have illustrated above, the portfolio functions as a site for developing an integrative identity, which aligns with recent scholarship that examines how science communicators navigate different identities in communication spaces. Davies (2021), for instance, has written about front-stage and back-stage identities of science communication, distinguishing between what we show people in public communications about science versus the complex science at work behind the scenes. In a sense, the NSC ePortfolios offer students a space to mediate between these two frameworks, giving students a place to articulate both their "back stage" and "front stage" selves, the researcher and the communicator, the public/personal persona and the academic, thereby integrating what might otherwise be a fragmented identity.

Evidence of Learning: Growth and Development as Science Communicators and Disciplinary Experts

Portfolios have often been used as a site of summative assessment to document a student's progress in accomplishing success, whether that be in terms of learning objectives, graduation requirements, or other extrinsic benchmarks. However, as Fuller (2017) and others have argued, it is equally productive to approach ePortfolios as an opportunity for formative assessment, where feedback (from peers, from instructors) can transform a static archive of artifacts into an impetus for intellectual growth.

Thus the very act of portfolio-building itself has an underlying formative imperative; as Fuller (2017) notes, the process of reflecting on and rationalizing the inclusion of artifacts selected for a student's ePortfolio promotes higher-order thinking and integrative learning, as students visibly connect knowledge across content areas to show evidence of learning. In this way, the ePortfolio itself operates as a site of active learning and growth.

In our analysis of the NSC ePortfolios, we found students realizing this goal of growth and development in a number of ways, including in their organizational metaphors and design. One pre-medical student chose an organizing metaphor around cell division, making explicit connections between the different steps in the cell division process and the steps that she had made on her journey to becoming a science communicator. Another student used an evolution metaphor, showing how he had grown from the "primordial soup" of his earliest science communication examples. Further, one student shared that even the color patterns were significant to her in helping to illuminate areas of growth.

> In this ePortfolio, each artifact category contains a series of three boxes: one blue, one pink, and one gold. Each color represents a different stage of development. Blue artifacts mark the beginning of an endeavor, where there is room for further improvement. Purple artifacts demonstrate growth from stage X to stage Y. Gold artifacts are relatively polished, incorporating the techniques I have learned thus far in communicating to specialist and non-specialist audiences. (Fan, 2018)

Beyond these design elements, the student reflection in the cover memo and individual artifact reflections also provided them with a key moment to articulate their intellectual growth. Many students shared that the process of reflecting on each artifact helped them to not only share their growth as science communicators, but also to understand how it happened in the first place. One student who studies coastal engineering wrote in her cover letter:

> I easily get scared and shy away from topics that are difficult to understand, and the artifacts…gave me a space where I could slowly process the dense basic information. As I wrote these papers and worked to understand the technical language used in this field, I told myself, "explain this to me as if I was a 5-year-old." I consciously chose this method to help myself understand the material; nonetheless, this method also unconsciously allowed me to practice communicating in a way that students in the beginning stages of their learning journey would understand. (Aye, 2022)

Several students noted that the process of selecting and curating visual elements also helped them to grow as science communicators by asking them to think in very concrete ways about how to communicate their message to a non-specialist audience. We encouraged them to include photos, illustrations, charts, maps, and other images that were a part of their learning experiences in all sections of their portfolio. Students shared that this process helped them to be more creative and to ensure that their scientific work was more accessible. One student noted that she learned

> how to make the information appealing to readers through visual elements or by filtering and emphasizing specific contents. These skills allow me to reach a broader audience than a conventional scientist who is trained only in science would, which I hope to use to further my environmental protection goals. (Tarsoo, 2022)

Similarly, another student noted:

> Through the Notation in Science Communication, as demonstrated by the works in this portfolio, I have learned how to communicate scientific topics to a range of audiences using a variety of methods… By including images and figures that build off of the text I help the reader to absorb the information from different sources. These are just a few of the strategies that I have gained from the NSC that help me to share my research with other scientists, get non-scientists excited about science, and communicate science that can inform people's daily lives. (Ferre, 2021)

Portfolio creation can help students avoid what Conefrey and Smyth (2020) call curricular fragmentation, an experience of undergraduate learning that is segmented into unconnected learning moments. For example, one student who focused on ocean science research used ocean metaphors to organize her portfolio as a way of demonstrating growth, taking her viewers on her learning journey over her four years at Stanford. She wrote:

> My science communication journey has been somewhat like a great day of tide pooling, one of my favorite coastal activities. The intertidal zone is a place to explore and learn, filled with colorful creatures and complex ecosystems. In Approach, I share moments where I learned the ropes of ocean science research. These artifacts are "firsts"—my first research paper, my first research poster and my first experience analyzing data. I then began engaging with science and translating research to a variety of audiences. In Engage, I highlight a shift in perspective, moving towards communication to non-scientists through blog posts and science briefs. Only after approaching and engaging can we find the tiny critters hidden in the rocks and understand the intertidal ecosystems that survive in an extreme environment. My final section, Discover, shares what science communication can be—the hidden stories and creative pursuits. Together, my ePortfolio showcases four years of exploration and growth. The ocean is full of opportunities for discovery and I've found that in my science communication journey. (Anderson, 2020)

In examples like this, we can see how students, with their nuanced use of metaphor, can articulate an integrated learning experience, one that helps them see their growth across different classes and contexts. In their study on a general education capstone pilot, Morreale et al. (2017) argue that this sort of integrative function is crucial to forward transfer for knowledge and skills, that ePortfolios "provide a mechanism through which students can critically review content from disparate general education classes and make connections across them, integrating their work to make broader knowledge connections that can be more easily leveraged and applied to new learning situations" (p. 13).

Perhaps one of the most important outcomes is that students have acquired a sense that learning is ongoing: that they are not working toward an end of static perfection but rather are instead acquiring a growth mindset that will allow them to continue to develop and adapt in different contexts. In the words of Laura Wenk (2019), writing about her experiences with portfolios at Hampshire College, we are helping students grow into "lifelong learners."

It's not possible to practice a growth mindset that enables lifelong learning without students recognizing the opportunity to learn from failure. As we mentioned above, students are required to include a "Room for Growth" artifact in their 99A introductory mini-portfolio; our graduating seniors are encouraged to upload artifacts that are not completely finished or did not turn out as well as can be expected. By including a less-than-perfect artifact in their final ePortfolio, students are afforded the opportunity to reflect on what they have learned from the experience, and how this learning has made them a more effective science communicator. As one student noted,

> [L]ooking back on my time in the Notation, I can see that I have learned as much from my communication failures as from my successes. Some of the most impactful artifacts in my growth as a science communicator have come in the form of creating something entirely ineffective—and learning from that defeat. (Howell, 2018)

Such learning from failure helps students understand that the ePortfolios are not finished products but rather capture a dynamic and multilayered picture of the students' learning journey in progress, one that will inevitably be filled with both set-backs and successes.

Making an Impact as Scientists and Science Communicators: Increasing Awareness of What It Means to Be an Engaged Citizen

A natural continuity to this forward-focus in the portfolios is student emphasis on the impact they could make beyond their undergraduate years as science communicators. This finding attests to the pedagogical design of our NSC curriculum, which emphasizes connections between student interests, their academics, and real-life implications. It represents a marked difference from Morreale's (2017) observations in her general education ePortfolio pilot, where the teaching team found that many of the students' reflective essays ended up being more personal autobiographical narratives with an inward focus upon self rather than outward, global issues. She notes that the majority of critical thinking was represented through individual artifacts conceptualized as unique assignments.

Our explicit focus on science communication might help students to move beyond the personal to making more integrated, global connections between their learning and the impact they want to have. As the many examples above demonstrate, consistently in their reflections, NSC students spoke to the impact that they want to have as scientists and science communicators in the broader world. It had been framed for them—and understood by them—as one of the primary goals of the capstone and effective science communication. There were direct connections between the learning manifest in the portfolio and their desire to have a positive impact in the world. For example, one student

described the focus of the portfolio on the ways their work "can inform, advance and serve." The student wrote:

> I start with my work that serves knowledge, which highlights technical artifacts within the scientific community. These artifacts represent scientists communicating with other scientists. Then I turn to my work that serves communities, which focuses on artifacts that reveal health disparities and propose community-specific solutions. Finally, I end with my work that serves policies, artifacts that synthesize information to inform policy decisions. (Elliott, 2020)

After graduation, this student went on to work as a contact tracer during the COVID-19 pandemic, and is currently pursuing a master's in public health. This student is not alone in this sentiment or choice of service; many NSC students are deeply invested in health and plan to have careers in public health, whether it be as a policymaker or a medical doctor. For instance, another student who studied eating behaviors in an effort to promote public health used her cover letter to write about the different kinds of impact she could have as an effective science communicator:

> As a science communicator, I can help people reimagine healthier built environments by amplifying the findings of scientists in podcasts, popular articles, and short videos that non-specialist audiences can more easily connect to. I can empower target subpopulations through the research, distillation, and dissemination of evidence-based information. Furthermore, I can challenge societal status-quos, such as the normalization of calorie-dense and nutrient-poor food, that oppose human health. In many of my science communication projects, I aim to ensure that healthy behaviors become the default behaviors, in order to prevent long-term consequences. (Blanco, 2022)

Another student, who also hopes to do advocacy work by researching the social determinants of health, specifically on how social discrimination and insensitive healthcare can adversely affect long term health outcomes, wrote about how she has learned to combine her science communication expertise and advocacy work for maximum impact. She reflected:

> In an ideal world, I could work in an LGBTQIA+ clinic focusing on infectious disease transmission. I want to use my French and Spanish to address a variety of patients and best understand individualized social barriers to healthcare. Through my science communication knowledge and passion for social good, I hope to continue advocating for patients in my future career, such as through organizations like Planned Parenthood, by integrating microscopic biology with the public health implications of sex differences and empathetic healthcare (Bellon, 2021).

The ePortfolio gave them a home for storing and showcasing their artifacts that reflect the impact they have had, and thus served as a powerful reminder of the impact their work has had and the impact they would continue to have in their careers.

To see this impact firsthand, we invited five NSC graduates to participate in a panel discussion about how they use science communication in their careers. These alumni described their work in community organizing, public health, climate policy, institutional communication, and product management, making thoughtful connections between what they had learned in the NSC and their professional work. What stood out the most from this panel was how the students described the impact that their jobs had—on the climate crisis, on the COVID response—and how the NSC had both

influenced their choice of career and provided valuable skills through their coursework and ePortfolio. As the alum who works in climate policy stated:

> It's a rewarding job because every day I get to practice science communication and dig even deeper into different topics…and it's been a really rewarding journey because I've been able to really build off the NSC, but I've also learned a lot of things since college… The best communication lands when you know what your audience is asking, and you meet them where they're at and use the language that they're demanding. But also when you know when to push and kind of, what is the way in, so that again, you can create action, so you can change their mind about something (Hutchinson, 2022).

Conclusion

During the very first ePortfolio class when students are brand new to the NSC, we ask them to consider the advantages and affordances of an ePortfolio. They share their answers anonymously on a digital comment board so that we can all read them on the screen together. Their responses reflect the many benefits of an ePortfolio and why students are excited about them:

> The portfolio provides a story of your experiences.
>
> [It is] able to show the driving forces behind our passions.
>
> [It] allows us to show ourselves in the way we style the portfolio not only in the content we choose.
>
> Everyone learns differently so it makes sense to have a wide variety of mediums to share it with all the diverse people in our lives.

Students also liked that the ePortfolio is easy to share and is a living document—"rather than something stagnant—people can keep updating it," as one student stated. Many students appreciated that it offered a more complete picture of who the student was, rather than focusing on one or two skills. Although this is one of the first ePortfolio activities we do, it is always a joy to see how quickly students grasp the multiple purposes and their eagerness to jump in and start the process.

In this article, we have shown the way we have scaffolded the NSC ePortfolio curriculum over the years that a student participates in the NSC program and the ways this curriculum has both shaped and reflected student learning and growth as science communicators across a range of STEM fields. We found that, through creating the ePortfolio, a majority of NSC students were able to a) develop a way of communicating their integrated personal and professional identities, b) show their growth and development as disciplinary experts and science communicators, and c) share how they have made an impact as scientists and science communicators through their increasing awareness of what it means to be an engaged citizen.

As we have shown, the root of the NSC curriculum is developing the students' capacity to engage in thoughtful and intentional reflection on their work, a process that many students say is particularly unique to their academic experience. Carol Rodgers (2002) wrote, "Reflection is a meaning-making process that moves a learner from one experience into the next with a deeper understanding of its relationship with and connections to other experiences and ideas" (p. 845). Reflection is an active process critical to integrating learning, making links across academic quarters, disciplines, and curricula and between coursework, personal, family, and community life. When students are given the opportunity to move from experience to description, analysis, and application of insight to new

actions (Rodgers, 2002), they can "ameliorate curricular fragmentation…making connections between concepts and content… In this way, ePortfolios bring coherence and cohesion to students' studies and demonstrate the plethora and diversity of student learning…" (Conefrey & Smyth, 2020, p. 15).

For students in the NSC this has meant integrating learning, experiences, and identities as both scientists and science communicators who will have a meaningful impact on the world. Students enter our program with a general understanding that science communication is necessary for the successful application of scientific knowledge to real world problems. Structured ePortfolio curricula, such as ours, can provide an institutional home for students, regardless of their specific major or disciplinary focus, who are interested in the emerging discipline of science communication. And, through the active creation of the ePortfolio, these students can complicate, deepen, and expand not only their understanding of the importance of science communication, but also the fundamental recognition of their place in the world as effective science communicators. As one student wrote, "The NSC…gives us the space to recognize, appreciate, and showcase the skills we're gaining in our undergrad careers in a really beautiful way. Our portfolios are a testament to our curiosity about the world and to what is most important to us as storytellers."

Appendix: NSC ePortfolio Evaluation Rubric

Criteria	**Pass with Distinction 4 pts**	**Pass 3 pts**	**Pass with Revision 2 pts**	**No pass 1 pt**
Purpose — Learning and Growth	ePortfolio as a whole shows student's exceptional achievement of NSC LOs and growth as a communicator; Learning and growth clearly situated within student's broader academic and/or professional identity	ePortfolio as a whole shows student's sufficient achievement of NSC LOs and growth as a communicator; Learning and growth situated within student's broader academic and/or professional identity	ePortfolio as a whole does not fully show student's achievement of NSC LOs and/or growth as a communicator; Limited discussion of broader academic and/or professional identity	ePortfolio as a whole does not show student's achievement of NSC LOs and/or growth as a communicator; No discussion of broader academic and/or professional identity
Cover Letter	Cover letter provides an engaging introduction to the ePortfolio purpose; Provides well organized framework for exploring ePortfolio	Cover letter sufficiently introduces ePortfolio purpose; Provides framework for exploring ePortfolio	Cover letter does not fully introduce ePortfolio purpose; Framework may be confusing or missing	Cover letter does not introduce ePortfolio purpose; Framework may be missing

Other Reflections	Reflections strongly connect artifacts to purpose; clearly contextualize artifacts; highlight LOs; identify areas of growth, and show application of learning	Reflections connect artifacts to purpose; sufficiently contextualize artifacts; highlight LOs; identify areas of growth, and show application of learning	Reflections inconsistently connect artifacts to purpose. May have issues with elements of context, learning, growth, and/or application	Reflections do not connect artifacts to purpose. May be missing elements of context, learning, growth, and/or application
Artifact Curation	Artifacts provide strong and convincing evidence of learning as described in reflections. Wide variety of genres and modes represented	Artifacts provide sufficient evidence of learning as described in reflections. Variety of genres and modes represented	Artifacts provide inconsistent evidence of learning as described in reflections. Limited variety of genres and modes represented	Artifacts do not provide evidence of learning as described in reflections. Minimal variety of genres and modes represented
Design	Creative site architecture and visual design enhances ePortfolio purpose	Purposeful site architecture and visual design supports ePortfolio purpose	Issues with site architecture and/or visual design limit understanding of ePortfolio purpose	Confusing site architecture and/or visual design detracts from ePortfolio purpose
Mechanics	Clean copy with minimal to no typographical or grammatical errors. Mechanics and style support and may enhance ePortfolio's purpose	Relatively clean copy. Minimal typographical or grammatical errors do not significantly detract from ePortfolio's purpose	Inconsistent copy. Typographical or grammatical errors distract viewer and detract from the ePortfolio's purpose	Unfinished, drafty copy. Typographical and/or grammatical errors significantly distract viewer and detract from the ePortfolio's purpose

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Notes

[1] Thank you to the NSC alumni who gave us permission to highlight and discuss their ePortfolios in this article. Thanks also to our colleagues in the Program in Writing and Rhetoric who have helped develop and support the NSC program over the past decade.

[2] The Vice Provost for Undergraduate Education houses units fundamental to all undergraduate education outside the major, such as Academic Advising, Overseas Studies, summer enrichment programs, and programs that deliver first-year and second-year general education requirements, such as the Program in Writing and Rhetoric.

[3] (A) shows the writing and communication courses that are required of all students. One class is taken each year, culminating in a final capstone project or thesis. (B) shows the NSC course sequence. These courses are taken by students who have been accepted into the NSC program, typically beginning in a student's sophomore year.

[4] Upon graduation, students have the option to fill out a form, approved by the university administration, that gives their consent for the Notation in Science Communication to share their NSC ePortfolio for "pedagogical, professional development, promotional, and research and presentation purposes" and that allows students to specify if they consent to have work shared in their own name or anonymously. Individuals can revoke their consent at any time.

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