

Reflecting, Integrating, and Communicating Knowledge Through ePortfolios to Increase Civic and Scientific Literacy

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Many students view their classes as separate and disconnected from each other and their lives beyond the classroom. Additionally, STEM students may fail to understand how concepts and formulas of introductory classes relate to practical applications of upper-division coursework and may perceive required general education courses as even less relevant. We suggest that implementing ePortfolios throughout students' academic programs can ameliorate this curricular fragmentation by bringing coherence and cohesion. Using their ePortfolios, students can reflect on connections between concepts and content inside and outside their major as well as other high-impact practices such as undergraduate research and intensive writing. Using examples drawn from the natural sciences and humanities, we demonstrate how ePortfolio pedagogy can help integrate curricular knowledge into solutions for authentic, real-world STEM problems to increase student motivation and understanding of the applications of their learning. Furthermore, it can help students develop the critical thinking and communication skills necessary to share their learning with a wide variety of audiences including instructors, program assessors, potential employers, and community members. Finally, we discuss how ePortfolios have the potential to enhance students' digital citizenship and civic scientific literacy to foster civic engagement upon graduation.

College students are facing increasing pressure as tuition costs continue rising and the future of work remains uncertain. In the age of automation and a knowledge-based economy, research suggests there is no longer a direct correlation between particular majors and specific careers but, rather, employers who are looking for intellectual agility, people who can adapt and evolve. To succeed in the workplace, graduates must be capable of taking initiative, working collaboratively, solving capacious problems, and transferring skills from a familiar to a novel domain (Dorman & Brown, 2018; Hood, Holtzman, & Abbott, 2019; National Association of Colleges and Employers [NACE], 2019; National Leadership Council For Liberal Education and America's Promise, 2007; World Economic Forum, 2016). However, educators and employers are finding that graduates struggle to integrate their learning across the breadth of their courses and over time. While their resumes list their course work and co-curricular activities, students fail to articulate how their education translates into workplace skills that could be applied in future careers. At interviews, even high-performing students with a lengthy list of relevant extracurricular activities are hampered by an inability to explain clearly how they meet the employer's needs and expectations, or to demonstrate what NACE (2019) has defined as *career readiness*, "the attainment and demonstration of requisite competencies that broadly prepare college graduates for a successful transition into the workplace" (para. 3), and what the Association of American Colleges and Universities labels *essential learning outcomes* (Hood et al., 2019).

Our students' difficulty in being able to abstract transferable skills from their coursework is rooted in our current higher education model, which fragments

the curriculum. Instead of viewing their academic programs holistically and understanding how skills such as critical thinking and written communication are practiced throughout the curriculum, students tend to view their classes in different programs across the college as discrete and disconnected from each other, so that quantitative skills, for example, are seen as the purview of math courses and writing is of English classes. A consequence is that STEM majors in first-year composition who complain that general education requirements squeeze out more relevant courses may struggle later in their academic careers to complete an adequate literature review, structure their senior design capstone reports, or create an effective resume and cover letter. This disconnect is prevalent even within courses in the major. Incoming STEM students may not understand how the concepts and formulas of introductory classes relate to the practical applications that they will learn about in upper-division courses. If students fail to integrate these foundational concepts and their learning across general education courses, they may switch out of STEM fields or persist but struggle in later coursework and flounder on the job market because they are unable to map their learning onto skills sought in the workplace.

As biology and English professors, we suggest that implementing ePortfolios throughout STEM students' academic careers can help mitigate curricular fragmentation, encourage more integration of high-impact practices (HIPs) and ease students' transition once they graduate. Both our ePortfolio assignments use writing and reflection as tools for improving written communication and as tools for learning and discovery. Rather than linking liberal education solely to vocational ends, we

believe that ePortfolios can foster intellectual growth, creativity, and civic engagement as well as marketable skills. We suggest that ePortfolios, when done well, can help students develop the cognitive awareness necessary to integrate their learning throughout their academic program and their extracurricular activities. Building an ePortfolio helps students foster digital communication and develop an intentional digital identity so that they can demonstrate to employers that they possess the most sought-after workplace competencies: critical thinking/problem solving, teamwork/collaboration, professionalism/work ethic and oral/written communications (Blumenstyk, 2019; Hood et al., 2019; McGraw-Hill, 2019; Peck, 2018).

In addition, these same competencies sought by employers and developed in ePortfolio pedagogy can help prepare students for intelligent, responsible and creative citizenship. These include civic scientific literacy: the ability to find, evaluate, and synthesize information about science and technology to make informed decisions as a consumer; as a citizen voting on STEM policy issues and as an educated individual with an understanding of the scientific method (Shen, 1975); and digital citizenship: the ability to engage in online formats respectfully and thoughtfully with those of different beliefs and values to make their voice heard, to evaluate the credibility of online sources, and a basic understanding of social media and how the internet works (Mossberger, Tolbert, & McNeal, 2008). Such skills can help them become life-long learners who contribute their knowledge to their communities, individuals who can synthesize what they learn from all forms of experience to make effective connections between theory and practice for the increasingly complex issues we face and who know how to communicate effectively with different kinds of audiences.

Reflection and Learning

Concerns over students' abilities to apply fundamental concepts in introductory general education classes to authentic problems in undergraduate research and complex issues discussed in upper-division courses in their major are not new. As institutions began grappling with how to better prepare their graduates to work on open-ended, multi-layered, interdisciplinary problems in the real world, it became clear that the ability to integrate one's learning was more essential than ever. In the early 90s, as higher education think tanks and task forces were being formed to explore the skill sets needed for ever-more technologically sophisticated workplaces and increasingly interdependent, global challenges, the importance of integrative thinking to make informed decisions in professional and civic life was already recognized. For example, the Association of American Colleges and Universities published a series of monographs called

The Academy in Transition as part of this effort. As Leske noted in the forward to *Integrative Learning*, "in most fields except education—from the workplace to scientific discovery to medicine to world and national affairs—multilayered, unscripted problems routinely require integrative thinking and approaches" (Huber & Hutchings, 2004, p. iv).

As one of the most effective ways to foster integrative thinking, scholars have focused on reflection. Much has been written about the value of encouraging students to reflect on their learning and teaching them effective strategies for doing this well. Dewey (1933) described reflection as a process of making sense of experience, connecting one experience with another, and anticipating future learning. Similarly, Kolb's (1984) experiential learning cycle identified reflecting on experiences, abstracting knowledge from them and testing these tentative concepts by applying them to novel situations. Bandura (1986) highlighted its importance in increasing self-efficacy, the belief in one's ability to be able to do something that comes from reflecting on past experiences, observing others, verbal persuasion and one's emotional state. Yancey (1998) drawing on philosopher Donald Schön's (1983) concept of "reflection in action" focuses on the role of reflection in enhancing the teaching of undergraduate composition. Similarly, Rodgers (2002), referencing Dewey's writings, stresses the importance of reflection not only for students but also for teachers to understand how and what their students are learning. Activities and incentives to encourage reflection are important practices to foster students' ability to connect their learning across time from discrete assignments in courses within their major and across general education requirements. Students' integration of their knowledge based on reflection also leads to improvements in metacognition and self-regulation, which in turn leads to an increased sense of an academic identity and increased academic persistence (Conefrey, 2018a; Ertmer & Newby, 1996; Pintrich, 2002; Schraw, Crippen, & Hartley, 2006). Although learning and reflection impact one another such that consistent and effective reflection leads to improved learning, the inclination and ability to reflect does not come naturally and instead requires nurturing, prompting, and practice (Douglas, Peecken, Rogers, & Simmons, 2019; Howitt & Wilson, 2016; Light, Chen, & Ittelson, 2012). Without practice in identifying connections, students are unlikely to view learning in one course as related to learning in another and may fail to realize the built-in scaffolding within a course. Similarly, without encouragement and incentives to reflect on their learning, students are unlikely to practice this skill regularly and consistently well (Harring & Luo, 2016; Watson, Kuh, Rhodes, Light, & Chen, 2016).

ePortfolios Across the Disciplines

While reflection is possible in any medium, the creation of digital tools for reflection and the advent of cloud computing has provided additional affordances for curating various kinds of artifacts and enabled students to reflect anywhere, any time, and on any device. Peet et al. (2011) identified various dimensions of integrative learning that can be developed through ePortfolio pedagogy: the ability to identify, demonstrate, and adapt knowledge gained within and across different contexts; to adapt to different people and contexts to provide solutions; to understand oneself as a learner (metacognitive awareness); and to create an intentional digital identity. In addition, compared to paper portfolios, a potentially transformative aspect of ePortfolios is that they provide a flexible place and space for students to incorporate multimedia, evidence of their learning for themselves and others, and reflections on their learning across courses and throughout their academic careers and beyond (Cambridge, 2008; Chen & Black, 2010; Jenson & Treuer, 2014; Morreale, Van Zile-Tamsen, Emerson, & Herzog, 2017). Compared to other tools and technologies for reflection and integration of learning, ePortfolios also provide the most flexibility in practicing rhetorical strategies for communicating with multiple and diverse audiences and for keeping pace with students' evolving academic careers.

ePortfolio pedagogy also helps with learning how to reflect well (Landis, Scott, & Kahn, 2015) because it provides opportunities for students to obtain feedback on their writing, which is important because deeper reflections are possible when initial thoughts and observations are shared and discussed with others (Yancey, 2009). Where developmental feedback and scaffolding are offered, the quality of students' reflection improves and some reach a level of *integrative meta-reflection*, where they can reflect on their reflections (Schrand, Jones, & Hanson, 2018). In this way, ePortfolio pedagogy leads to students taking more responsibility for their own education and becoming more intentional about how and what they learn, what they share, and who they share it with as they develop their professional, digital identity (Peet et al., 2011).

From the early adoption of ePortfolios in humanities programs that would formerly have used some kind of print portfolio assignment for student assessment, ePortfolios have proven themselves to be more beneficial than print in numerous ways (Yancey, 2009). Research by Bowman, Lowe, Sabourin, and Salomon Sweet (2016) comparing reflections in first-year writing in print and digital formats found that, while reflections in either format improved integrative learning, students using the digital format evidenced increased metacognitive skills and intentional learning.

From first-year writing to courses across undergraduate education to graduate and professional programs, ePortfolios have improved learning outcomes by strengthening integrative learning to connect students more closely to their chosen field (Batson et al., 2017; Light et al., 2012; Reynolds, Patton, & Rhodes, 2014). For this reason, ePortfolios are becoming increasingly common in institutions and programs with capstone requirements. For example, (a) Cordie, Sailors, Barlow and Kush (2019) reported on their use in three different programs at a large land-grant university; (b) Morreale et al. (2017) discussed their usage campus-wide at a large research institution; and (c) Schrand et al. (2018) described their introduction at a small, private university. Similarly, providing evidence from the Connect to Learning project, an initiative comprising 24 institutions, Eynon and Gambino (2017) found that ePortfolios were beneficial across all institutional types and programs in supporting the integration of student learning, development of a scholarly identity, and promoting overall improved academic outcomes.

In recognition of the potentially powerful impact ePortfolios can have on learning gains, they have recently been declared the eleventh HIP (Watson et al., 2016). While ePortfolios alone are beneficial, an increasing body of research suggests that where they are combined with other HIPs, the benefits are cumulative and participating in multiple HIPs is particularly advantageous for first-generation, low-income, minority, and other traditionally underrepresented student populations (Conefrey, 2018b; Finley & McNair, 2013; Kuh, 2008; Reynolds et al., 2014). These findings suggest that an important affordance of HIPs is their ability to promote integrative learning from both academic and co-curricular activities, that is, to help learners "reflect on their understandings, reconcile new ideas with old ones, and integrate learning from one setting to be useful in other settings" (Tukibayeva & Gonyea, 2014, p. 13). Because of their ability to act synergistically with other HIPs to amplify their benefits (Conefrey, 2018a; Hubert, Pickavance, & Hyberger, 2015), some have labeled ePortfolios a "meta-HIP" (Watson et al., 2016).

ePortfolios for Professional/Career Development

In addition to fostering integrative learning, undergraduate programs are also understanding the benefits of using ePortfolios to promote more intentional learning and a professional digital identity. As they progress in their academic programs and curate their learning in ePortfolios, they begin making the transition from viewing themselves as students to imagining themselves as scientists, researchers, and engineers. When this process begins, students start becoming more active participants in their own

educational journeys and taking more responsibility for charting their own life's course. The emphasis on reflection encourages students to reflect on what they are learning in a single course, all the courses throughout their academic careers, and their co-curricular and extra-curricular activities. Students who are exposed to ePortfolio pedagogy early and often in their academic careers come to understand that learning from all these disparate settings can be integrated and applied to novel settings. Jones and Leverenz (2017) noted that students are often more motivated when they realize that their ePortfolios can be used not only to satisfy course requirements but also to showcase their skills for future employers, graduate school applications, or other external audiences.

Part of this process, especially for juniors and seniors, involves students developing a professional identity as ePortfolios provide an opportunity for students to try on new personas, integrate new identities with older ones, decide how they want to present themselves to potential employers, and field test how they are received and perceived by viewers. Presenting themselves in their ePortfolio requires that they reconceptualize their audience as broader than their instructor and classmates and begin to understand how viewers bring their own understandings, experiences, and expectations to the ePortfolio. A well-crafted ePortfolio with effective content can help students fashion a professional identity and combine their academic, co-curricular, and extra-curricular experiences so that an employer can more easily appraise their knowledge and skills (Benander & Rafaei, 2016; Gallagher & Poklop, 2014; Ramirez, 2011). Lynn Pasquerella (2019), President of the AAC&U (Association of American Colleges and Universities), asserted that high-impact learning opportunities engage every student in solving unscripted, real-world problems across all types of institutions and noted that "business executives and hiring managers find ePortfolios containing artifacts of demonstrable skills more helpful than college transcripts and resumes alone when evaluating and hiring recent graduates" (para. 8).

Recognizing the importance of ePortfolios in career planning, some institutions such as Virginia Tech (McNair & Garrison, 2012) and Stanford (Chen & Patel, 2017) have dedicated courses for students seeking to build their digital brand for the job search. The benefits persist whether or not the potential employer reads the student ePortfolio. The exercise of creating it is valuable for interviews because, as Cordie et al. (2019) noted, having created a narrative to organize their ePortfolio, candidates are better prepared to address common interview questions such as "Tell me about yourself?" and "What distinguishes you from other candidates for this position?" The metacognitive

and flexible learning skills that they learn can make these graduates stand out from others. ePortfolios, when done well, provide evidence of the competencies identified by NACE (2019): critical thinking, oral communication, written communication, teamwork, digital technology, leadership, professionalism, and career management. These are skills that employers often find lacking in recent graduates (Watson, 2019; Wear & Baltazar, 2019).

ePortfolios in STEM

Where ePortfolios have been slower to take off is in lower-level and general education undergraduate STEM courses. As a result of disciplinary silos and the need to "cover" large amounts of basic concepts, writing (and reflection) has typically been viewed as the purview of the literature faculty. However, institutions that have begun incorporating ePortfolios into their science courses have found them to be highly beneficial. Singer-Freeman, Bastone, and Skrivanek (2014), who implemented ePortfolios in a summer research program for underrepresented minority students, found that they increased students' sense of academic identity, scholarly community, and future orientation. Their research confirmed that the learning gains were even greater for those traditionally underrepresented in STEM fields, and that the gains could be assessed by both the faculty who were familiar with the students and other faculty who were not (Singer-Freeman, Bastone, & Skrivanek, 2016). More recently, Singer-Freeman and Bastone (2017) found that in a growth mindset intervention (Dweck, 2007), students using digital portfolios acquired greater benefit than those using print portfolios. Similarly, Picardo and Sabourin (2018) found that biology and chemistry majors in a 10-week summer research program reported greater learning gains when they received guidance with reflection and created an ePortfolio to showcase their learning when compared to those in a comparable cohort who did not practice reflection or create ePortfolios. Moreover, the reflections of those in the ePortfolio cohort demonstrated evidence of professional identity development and increased self-efficacy (Bandura, 1997; Hunter, Laursen, & Seymour, 2007). Similar gains in terms of engagement and persistence were found in undergraduate biochemistry curriculum at six campuses that recently implemented ePortfolios (Mills et al., 2017) and in biology courses for majors (Haave, 2016; Johnston, Kant, Gysbers, Hancock, & Denyer, 2014) and non-majors (Fuller, 2017).

As awareness grows of the value of HIPs in improving undergraduate STEM retention, ePortfolios pedagogy is increasingly supported by national science pedagogy-focused organizations such as SENCER (Science Education for New Civic Engagements and

Responsibilities). The use of ePortfolios in undergraduate science courses has been shown to amplify the impact of undergraduate research and promote the SENCER ideals of civic scientific literacy and civic engagement by enabling students to engage with multiple audiences and share their work more easily. Sieg et al. (2019) have previously piloted the use of ePortfolios in biology and physics courses at two different, small liberal arts institutions to showcase and display undergraduate science research and projects connected to real-world problems. For SENCER faculty at institutions that have struggled historically with student retention in STEM majors and lack the resources to fund much undergraduate research, ePortfolio pedagogy appears to increase the benefits of classroom-based undergraduate research experiences (CUREs) and project-based learning (PBL), two options for providing undergraduates with research experience and helping them integrate curricular knowledge into solutions for authentic science issues to improve engagement and retention. In their reflections, students wrote how combining CUREs and PBLs with ePortfolios had improved their communication skills, made the course more engaging and offered greater opportunities for collaboration and interaction with faculty and peers (Sieg et al., 2019). Although it was too early for faculty to assess specific gains as a result of these interventions, they were able to report that more of their students were considering graduate programs, receiving research fellowships, internships, travel awards, and presenting at national conferences. Similarly, KEEN (Kern Entrepreneurial Engineering Network), a national engineering-education association has recently established a Subnet in 2019, called LEARN (Learning Through Evidence-Based Authentic Reflection and Networking), where members share best practices for using ePortfolios in undergraduate engineering courses. Their annual meetings also feature an increasing number of presentations by faculty piloting ePortfolios with the goal of using them as a curriculum-wide approach to develop an entrepreneurial and professional mindset in engineering students.

Ideas for Getting Started if You are New to ePortfolios

Faculty who are new to ePortfolio pedagogy and whose institutions lack top-down support might consider adding ePortfolios to their courses by adapting existing assignments rather than trying to make too many changes at once. For example, print-based reflection assignments could be assigned in a digital format with the added advantage that students could include multimedia in their responses, discussion posts could be assigned as blogs with students commenting on each other's posts, and digital stories could easily be uploaded to portfolio platforms. New ePortfolio adopters should be aware, however, that there can be challenges with students'

motivation and confidence in using their ePortfolios. Douglas et al. (2019) found that seniors and those who had prior experience with ePortfolios tended to make better use of their ePortfolios than juniors and those who were less experienced with the technology. Other concerns include platform choice, adequate training for both faculty and students in technical aspects of creating ePortfolios, and privacy issues (Eynon, Gambino, & Török, 2014). In addition, to be the most effective, ePortfolios must be implemented well and should evidence the eight qualities that Kuh and O'Donnell (2013) have listed: (a) high expectations for quality work, (b) significant investment of time and effort by students over a period of time, (c) frequent feedback on work in progress, (d) meaningful interactions with faculty and peers, (e) opportunities to reflect on and integrate learning, (f) opportunities for experiences with diversity and real-world applications, and (g) demonstrations of competence for external audiences. Integrating ePortfolios across the disciplines and throughout students' academic careers is the ideal way to maximize their synergistic potential and to enhance their use for academic advising (Ambrose, Bridges, Dipietro, Lovett, & Norman, 2010), and assessment. Currently ePortfolios can be used for program assessment and accreditation in many fields by using AAC&U's VALUE Rubrics (Rhodes, 2014); however, available rubrics work less well for STEM disciplines such as Biology.

ePortfolios can be slow to take off institution-wide as it takes some trial and error to sell them to colleagues and students, and it may also be helpful to join national associations which promote the use of ePortfolios across the curriculum in undergraduate education such as AAEEBL (Association of Authentic, Experiential, and Evidence-Based Learning) and AAC&U. Additionally, as noted above, some national science education associations such as SENCER and KEEN have subsections devoted to educating and informing members about ePortfolio use in STEM fields. Other valuable resources include journals such as the *International Journal of ePortfolio* (IJeP), the *AAEEBL ePortfolio Review* (AePR), and other occasional publications from the AAC&U focusing on ePortfolios. Comprehensive guides from leaders in the field (e.g., Batson et al., 2017; Eynon & Gambino, 2017; Light et al., 2012; Reynolds et al., 2014) are also invaluable.

Case Studies: ePortfolios to Promote Civic and Scientific Literacy Across the Disciplines

As described earlier, a newer but promising area of ePortfolio implementation is in undergraduate STEM pedagogy to increase motivation, engagement and retention of undergraduates in these fields. Drawing on examples of student ePortfolios from pilot implementations in natural sciences and applied

Figure 1

Excerpt from Student Reflection Essay on the Design of a Toilet Demonstrating Integration of Classroom and Real-World Knowledge

Ind 4 – Journal Entry Week 3

Posted on October 14, 2019 / Under [Uncategorized](#)

/ With [0 Comments](#)



Two of my grandma's friends who live in the city have this sort of bidet attachment that was added to their otherwise normal-looking toilet. This was the first time I've ever tried a bidet, and I'm not sure how to feel. I understand how much cleaner that is, and really, it does make more sense to wash down there with water, not just some think paper. However, I found it uncomfortably wet afterward. There was a dryer setting that was sort of a light fan, but that made me wonder how clean it actually was, especially if those hand dryers are bacteria-filled as well. So I tried using toilet paper to dry off a bit more, but that also didn't work very well.

Aesthetics- 3 (regular looking toilet, very clean)

Economy- 2 (added bidet seems expensive, the first time I've seen one, and that says something at least about affordability)

Sustainability- 2 (used a lot of water, to clean and to flush, no setting that was less water)

Note. Excerpt from student reflection essay on the design of a toilet demonstrating integration of classroom and real-world knowledge, particularly the statement about potential contamination of dryers by bacteria. This reflection also shows that the student demonstrated critical thinking in their use of the assigned rubric to rank the toilet design.

writing courses at our home institutions, we demonstrate how ePortfolios can be used to integrate other HIPs and curricular knowledge into solutions for authentic, real-world STEM problems to increase student motivation and understanding of the applications of their learning. We provide exhibits

from our students' work, showing evidence of student integration, reflection and communication. The examples demonstrate that they are developing the critical thinking and communication skills necessary to connect disparate ideas and to share their learning with a wide variety of audiences

including instructors, as evidence of their mastery of the course goals, and employers as evidence of marketable skills. We suggest that the skills students acquire through building their ePortfolios enhance their civic and scientific literacy to promote life-long, effective, digital citizenship. They graduate with the potential to become informed and engaged

citizens who are skilled at using digital tools to research and communicate effectively on science and technology issues affecting themselves and their communities. We round out our discussion by describing some of the challenges associated with ePortfolio implementation, offering possible solutions to mitigate them.

Figure 2
Excerpt From Student Reflection About Toilet Access

Toilets Change the World: Ind 11

Posted on November 4, 2018 / Under [Toilets Change the World](#) / With [3 Comments](#)

This week in class we analyzed data organized by Overflow Solutions Data, about the percentage of Americans without a flushing toilet. I looked at Maryland and the District of Columbia, where I live back home. I was surprised to find that 1.11% of Marylanders who own a home, don't have access to the flush toilet system in their home. It's very shocking to think that people in my state don't have access to something as simple as a toilet. Also, I do know that Maryland isn't a state in bad shape, in terms of money, because Maryland is full of many affluent and powerful people because of our proximity to Washington D.C. I also checked the District of Columbia's data and found that about 2,137 out of the 306,184 homeowners in D.C. don't have a toilet. Both Maryland and D.C. have enough money and powerful people to solve this issue of toilet access, however, even in 2014, this is still an issue.



Note. By providing students access to data and the means to analyze the data, students are able to think critically about toilet access, actively integrating classroom learning with their real-life knowledge and experiences. Because most students consider toilet access a problem in other countries, particularly underdeveloped countries, which is not something connected to their lives, this activity provides an opportunity for students to reflect and communicate their thoughts and ideas when presented with data from their own states. In some cases, students were shocked when confronted with the data, as is evident in this example.

Figure 3
Excerpt From a Student's Microbial Profile Demonstrating Integration of Classroom Learning With Information Gleaned From Their Independent Research
 5/1/2024

Dear Diary,

So let's be candid for a second. We all know there are good and bad bacteria. There are bacteria that provide and support an ecosystem/microbiome, and there are ones that harm those environments. One example of a bad type of bacteria are pathogens.

In layman's terms, a pathogen is a bacteria that can cause disease. You might be asking if I am a pathogen and simply put: I am not. Because I am a *Vibrio fischeri*, I am not really pathogenic. However, my cousins *Vibrio vulnificus* and *Vibrio cholerae* are quite nasty pathogens. Cousin *cholerae* is responsible for making unlucky humans feel very sick. Cousin *c.* gives them the most unpleasant stomach issues like vomiting, mass-amounts of watery diarrhea, rice-water stools, abdominal pain and even low blood pressure and a rapid heart rate. My cousin sometimes even kills the people that they mess with. Now onto my cousin *Vibrio vulnificus*, sounds dramatic right? Cousin *vulni* causes similar symptoms in humans as my other cousin but also causes a rapid decrease in human health with skin and bloodstream infections. Sometimes the humans they infect are smart and take antibiotics which work to get rid of my cousins and make the humans feel better.

There are some bacteria that are antibiotic resistant. This can happen when the antibiotics introduced to the community of microbes only kills off the weak bacteria, leaving behind bacteria that are strong and resistant to that specific antibiotic and can even give their drug resistant DNA to other bacteria via a process called horizontal transfer which is a transfer of genes directly. This leaves only the strong ones to repopulate making a fresh 'batch' of antibiotic resistant microbes. It's a scary thought because this can lead to things called superbugs; which are, in some cases, practically indestructible pathogens.

I hate to leave this entry on a kind of sad note, but next time I promise we will talk about something nicer.

Love,

Ali <3

Note. Student creativity is also evident in the style and use of a diary format to communicate the information in a fun and engaging way. This assignment leverages the ePortfolio to highlight content knowledge, integration of knowledge, linking of learning to real-world issues, and effective and creative written communication.

Eugene Lang College of Liberal Arts at The New School

Eugene Lang College is one of the five divisions that make up the New School, a private institution with a mission to “prepare students to understand, contribute to, and succeed in a rapidly changing society, thus making the world a better and more just place” (The New School, 2020). At Eugene Lang, which has approximately 1,500 undergraduates, students do not

declare a major until their sophomore year and are encouraged to sample the varied curricular and cross-disciplinary offerings before they commit to a particular major. As part of a first-year experience (another HIP), all Lang students take a first-year seminar-based course, which features an embedded first-year peer fellow who helps them adapt to and integrate into college life. These courses are taught by a variety of Lang faculty and are not considered to be discipline-focused; rather, they serve to promote student literacy and writing.

ePortfolio usage is encouraged for the first-year students though few of the faculty employ their use in the course itself. This is in contrast to Parsons School of Design where ePortfolios have been embraced as a curricular innovation across 11 of its undergraduate majors. The transition from a paper-based/physical portfolio to an electronic version has been successful in studio classes at Parsons in which “the foundational qualities of art and design practice is innovation and generative thinking” (Doren & Millington, 2019). We noted that the ePortfolio process made visible the art and design practices that are not usually seen.

The Lang freshman seminar course, *How the Toilet Changed the World*, is the first course offered by a Natural Sciences faculty that incorporates ePortfolios. The assignment is based upon ePortfolio assignments used by Dr. Smyth at Mercy College via *Digication* in environmental science and microbiology classes (Sieg et al., 2019). In the course, students tackle the topic of toilets, the science behind the invention, the history of the toilet, and how important they have been and continue to be across the world. The course takes students on a journey covering the development of epidemiology and John Snow, gender equity and access to toilets, public health and open defecation, technology, biogas, and the future of toilets. Like the courses being taught at Santa Clara, this course is writing-intensive and features several reading and writing assignments, case studies, games, and lab experiments. It has been deliberately designed to help improve students’ engagement with civic issues and problems of real-world import. The course features a semester-long collaborative project that involves designing a more sustainable, culturally sensitive, aesthetically pleasing and affordable toilet. The collaborative project allows students to integrate all of their classroom learning and research outside the classroom to develop a single prototype of the design. They also have the opportunity to research and apply their critical thinking to real world examples (Figure 1) and to reflect upon access and civic issues (Figure 2). Throughout, students reflect upon their learning weekly in ePortfolios and are asked to comment on their peers’ work. Using the ePortfolio this way provides the instructor with a pulse on student learning and their reflective process as they journey through their first semester at the college, and encourages students to communicate with their peers and the New School community via the ePortfolio and integrate their prior knowledge with their classroom learning.

In the foundation course *Microbial Ecologies*, students complete a semester-long research project detailing a specific microbe. This assignment was based upon ePortfolio assignments that were piloted at New York City College of Technology via the *OpenLab* (<https://openlab.citytech.cuny.edu>) in microbiology classes

taught by Professor Smyth. Unlike the freshman course, this course serves as a foundation course for the interdisciplinary science major and can also be taken by a variety of students in varying majors from fashion to environmental science to integrated design. The course has no prerequisites. The project is called *Getting Friendly with Bacteria* and serves to integrate both their classwork and independent research while demonstrating that integration visually and creatively in the ePortfolio (Figures 3 and 4). Students get to choose their microbe and, while a list is provided, students can propose another microbe that ties into their other interests (e.g., microbial pigments, food microbiology). Rubrics and writing prompts are provided based upon the core concepts of a standard microbiology course aligned with *Vision and Change*. The AAAS (2011) report “*Vision and Change in Undergraduate Biology Education: A Call to Action*” concluded that a change in how we taught our students was needed. It recognized the interdisciplinary nature of biological research, along with the ever-expanding complexity of biological data, and the associated power of emerging technologies (Horak, Merkel & Chang (2015).

The assignment is scaffolded to ensure timely completion of the task. Examples of previous semester’s work are also shown to the students. This assignment has been adapted to the New School by the inclusion of an additional task. Students create a public work that is entirely up to the students’ discretion but must feature the microbe from the portfolio. As the creative work is destined for the general public, it must be accessible to non-specialists. Students can write poems, make food, create works of art, knit microbes, and record songs and raps. This Spring we held our first *Marvelous Microbes Exhibition* celebrating the featured microbes. Each exhibit (e.g., showcasing painting, poem, story) was accompanied by a scannable QR code that linked to the student’s ePortfolio. This allowed attendees to visit the ePortfolio and to learn more about the featured microbe.

In all courses where ePortfolios have been used, the feedback has always been positive. From earlier versions of the assignments at Mercy College and CityTech, and in classes such as *Environmental Science* for non-majors and *Microbiology* courses for majors, students have always valued the ePortfolio experience. From our pilots at the New School, feedback from students in the end-of-course evaluations and their comments in their ePortfolio reflection assignments suggest that the students appreciated reflecting on their classroom learning in the ePortfolio. A student in the freshman course commented, “I feel that the most effective aspects of the course was completing the journal entries each week. It gave me a space to practice my writing, and also reflect on what I’ve learned.” In the *Microbiology* course, two students singled out the projects on the portfolio as the most effective activity,

Figure 4

Excerpt From a Student's Microbial Profile Connecting Their Microbe to the Solution of a Capacious Problem, Light Pollution

Sometimes I feel insignificant, I feel like people only know me because of Prymna!! Well, if I am being honest that is the only important thing my family and I have really done so far... but I see a big future for us. I particularly see a future for us in terms of helping or solving the light pollution problem that the modern world has. Speaking of, I'm reading an article right now that is telling me about all the problems of light pollution. They say that "Light pollution is excessive, misdirected, or obtrusive artificial (usually outdoor) light. Too much light pollution has consequences: it washes out starlight in the night sky, interferes with astronomical research, disrupts ecosystems, has adverse health effects and wastes energy." which is absolutely insane (Globe at Night)! I can see us revolutionizing the way the humans light our world. For example, if they can work with us and figure out a way to harness our abilities to provide light to city streets by replacing street lamps with us, then — in theory — light pollution could be addressed and would begin to be dealt with!! Wouldn't that be amazing? The more light pollution there is the worse our planet's condition gets, which sucks because light pollution gets worse and worse worldwide every single day. It is sad. I was doing some research and found a mock up of what a bioluminescent human city would look like and here is what I found!



<https://www.cnn.com/videos/tv/2016/10/25/make-create-innovate-bioluminescence-glowee.cnn>

Note. In this excerpt, the student is reflecting on the potential of their chosen microbe to serve as a solution to a civic problem. It also shows the student incorporating novel research that was not covered in the classroom. The student is also beginning to recognize and reflect upon the importance of synergy rather than competition with nature.

The debate at the end, the final project, the tour of the school, the continual dialogue about how this could be used in the real world/what is actually going on in the real world. . . . The projects of this course were very helpful and interesting to do such as tiny earth and getting friendly with bacteria.

The integration of ePortfolios into the Microbial Ecologies course is significant as it is a foundation

course for our major, one of the five that all Interdisciplinary Science students take. This means that all students in the major will have experience working with their ePortfolios. ePortfolios are now being piloted in subsequent science courses including the intermediate course Evolution, Mutation, Computation with a focus on integration, reflection, and communication of key concepts. A newly developed course, "Building your Career Ecosystem," is focused on developing the career

ePortfolio. By leveraging ePortfolios to not only satisfy course requirements and showcase their research and projects but also to highlight their skills and talents for future employers, graduate school applications, or other external audiences we hope to increase their motivation (Jones & Leverenz, 2017).

It is noteworthy that our presentation at recent conferences of our work in progress, namely at the SENCER Summer Institute in 2019 and the 11th Annual Forum on Digital Learning and ePortfolios in 2020, has led to additional faculty and administrators embracing ePortfolios as pedagogical tools at The New School. Dr. Anne Yust attended SENCER and is piloting them in her math course Quantitative Reasoning, and our Director of Curricular Initiatives has reached out to discuss possible expansion into other courses in other majors.

Santa Clara University

Santa Clara is known primarily as an undergraduate liberal arts institution, although it does have some (mostly professional) postgraduate programs. Regardless of major, all undergraduates must complete the university's core curriculum. However, despite Santa Clara University's (2020) goal to "reemphasize engaged learning, critical thinking, civic life, communication, and intentional learning" (para. 3), many students are unengaged in these required courses, which they believe to be less relevant for their future plans than courses in their major. As a way of encouraging students to make more effective integration across disparate courses inside and outside of their major, ePortfolios offer significant potential. The following section describes how the integration of ePortfolio pedagogy in a core writing course for STEM majors helps students understand the value of their learning beyond the classroom and the importance of developing a range of rhetorical strategies to communicate that learning effectively to both specialist and non-specialist audiences.

The course Writing in STEM focuses on technical writing and formats such as proposals, formal letters, resumes, technical presentations, and formal reports. As students represent a variety of majors and are often reluctant to devote effort to STEM content outside of their own major, the course connects to broader narratives around "fake news" and focuses on STEM issues of widespread public interest. For the major assignment, students research a controversial issue related to their major in both peer-reviewed journals as well as popular, credible media sources such as respected national newspapers and news magazines. Exploring topics such as whether to pay the higher premium for organic produce, drive an electric car, or purchase bottled water, or decide how much

information to divulge on social media, and so on, emphasizes the need to know about breaking news outside their own STEM field in order to make informed decisions for themselves as citizens.

To meet the course goals and build their ePortfolios, students complete several scaffolded assignments. For example, a Blog Post assignment requires them to read and analyze a science-based news article from a respected national newspaper that references published research. They then read the original research before writing a blog post, which takes a stance on how faithfully the news story represents the research findings. Reading both academic and popular sources affords opportunities for analyzing which writing style and rhetorical strategies are used for each audience and for what purpose. This focus on critical thinking and rhetorical strategies sets students up for the major assignment, Controversies in STEM, which is a report on a controversial issue in their STEM field. In preparation for the final written report, students gain practice in a variety of formats such as formal proposals, progress reports, literature reviews, and presentations on relevant peer-reviewed research on their topic to their classmates, a non-specialist audience. Students' oral communication skills culminate in a presentation to demonstrate the major findings of their final report, which can be uploaded to their ePortfolio. To anchor their ePortfolio, students also write a reflection essay as the final written assignment. In completing the reflection essay, they are tasked with reflecting on how their assignments relate to the course learning goals and objectives. The reflection prompt is as follows:

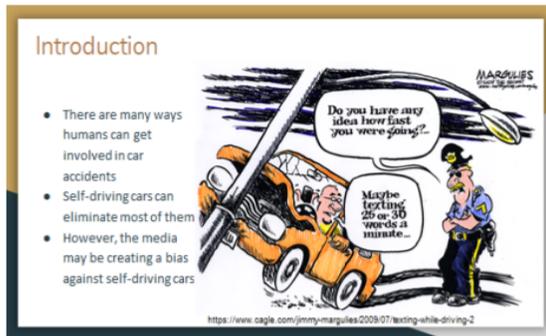
Describe what you have learned about writing in STEM. Possible questions that you could address include: What do you know about writing in STEM for different audiences and with different purposes that you didn't know before taking the course? What have you learned about locating and evaluating sources and selecting credible ones to provide evidence and elaboration for your ideas? How does what you have learned in this course relate to other classes that you are taking at Santa Clara University or your life in general? For each claim, provide evidence and support which can be text-based, graphics, video, or multimedia.

The excerpt in Figure 5 is sampled from the reflection essay of a computer science major who, in describing what he learned about how to critically evaluate different kinds of STEM sources, demonstrates he applied the learning objectives of the class to his project on self-driving cars and how that knowledge can be valuable in a broader sense.

Other students also mentioned their increased awareness of how the audience shapes the text and how an alert reader must consider the motives of the writer.

Figure 5

Excerpt from Student ePortfolio With an Oral Presentation Slide and Reflection Essay



I have learned that it is very easy for technical information to be misrepresented when presented to lay audiences. This means that the general public tends to receive a sensationalized, shallow perspective on a highly technical and nuanced topic. For example, an article I read for our report provided information on the crash statistics of self-driving cars. However, it only included the number of crashes, not the frequency of crashes. As a result, it made the companies which had driven the most (Waymo and Cruise) look like they also crashed the most frequently, since they had the highest number of crashes. However, this is not true; because they had driven the most miles, it was no surprise that they would have crashed the most.

Apart from a healthy skepticism of the media's interpretation of peer-reviewed science and increased alertness to the existence of fake news, some commented on how creating the ePortfolio helped them begin preparing for future careers and lives as engaged citizens. For example, a student majoring in public health wrote,

I am especially grateful to this class for the opportunity for modeling an in-depth examination of how media sources maintain fidelity to scholarly research. As I prepare to enter the healthcare industry as a research scientist, I am increasingly concerned about the lack of information and misinformation presented in non-scholarly sources about topics like vaccination, dieting, prescription drug use, insurance practices, and self-diagnosis and treatment of mental or physical illness. I firmly believe that scientists have the responsibility to not only carry out robust and replicable studies but also to make sure that well-researched science is communicated outside of the bubble of academia and into the public realm in a way that is understandable and accessible.

Emphasizing not only the value of science information being conveyed accurately and effectively

I also learned that technical articles can have their own form of bias. This is because sometimes companies commission researchers to write scientific articles for them about their products. Because these researchers are being paid by the company, they want to present the company in a favorable light. For example, while doing research on self-driving cars, I discovered that many reports on the safety of self-driving cars were commissioned by Google or other self-driving car companies. This meant that these articles focused on the positive sides of their self-driving cars, possibly misrepresented their crash statistics, and did not provide a completely objective analysis of their safety. For this reason, I realized that I also needed to investigate the researchers' backgrounds and their motives for writing the article. While working on the report on self-driving cars, I read many media articles and compared their content to corresponding content in scientific articles.



to the public, other students mentioned the importance of selecting appropriate rhetorical strategies for communicating effectively with decision makers. For example, one student noted,

As public health practitioners, we not only have a duty to educate the public (think nutrition, vaccines, sexual health), but the level at which we are able to make our case to people like lawmakers has the potential to shape legislation and impact health policy on a national scale.

As students begin populating their ePortfolios with their blog posts, written reports, and reflection essays, they may choose to add additional content such as their oral presentations, resumes, professional photographs, and sample assignments and projects from other classes. In addition to the Welcome page, which describes the purpose of the ePortfolio, students also create an About Me page after careful consideration (and in-class discussion) of how they want to present themselves digitally. In this way, they bring the same rhetorical awareness to their ePortfolios as to their other assignments, so that by the end of the course, students have created a personal website that is accessible to a

I iterated it a couple of times over the course of two weeks with the help of a few people in addition to the advice and tips given by the in-class speaker. In the end, I settled with two different designs that I am currently using for jobs that are more art focused and ones that are more programming focused (on my website, the CV page has the simpler one printed directly on the page and has the more in-depth version to download). I think they're both vast improvements over my previous versions; they're less bogged down by text and formatted for easier scanning. While they both deliver essentially the same information, each one caters to what might be expected per field.

Many seniors noted that with some modifications, such as including projects from their majors, their ePortfolios could be used to showcase their career readiness skills to potential employers to prepare for interviews even if the prospective employer did not visit their site. See Figure 6 for a sample page from a computer science major who demonstrates effective visual rhetoric and digital skills by providing a brief description of some of his projects and links for the viewer to explore in more depth.

Discussion

Our examples show how ePortfolios across the disciplines have been used at two very different programs at two very different institutions to strengthen students' abilities to apply what they are learning in their courses to authentic, real-world STEM problems such as toilet access in developing countries and in the United States, the impact of light pollution, and the so-called risk of autonomous vehicles, thus improving their civic and scientific literacy. As seen in our examples, students are using their ePortfolios to integrate curricular knowledge into solutions for authentic real-world issues and reflecting on how to communicate these issues to a variety of audiences. Such problem-based learning increases student motivation and understanding of how their learning could be used in future careers and applied to their lives as informed citizens. The exhibits from the ePortfolios demonstrate how students are developing the critical thinking and communication skills necessary to synthesize disparate ideas from undergraduate research lectures, course texts, peer-reviewed journals, and multimedia sources accessible to the public and to connect that learning to future careers. In creating these outward-facing ePortfolios and related exhibits, we have shown how students are practicing their oral and written communication skills in a variety of modes to share their learning with diverse audiences such as (a) to instructors, as evidence of their mastery of the course

goals; (b) to employers, as evidence of marketable skills; and (c) to general audiences such as family and friends, as evidence of how their academic learning connects to real-world applications. One of the benefits of ePortfolios is their capacity to encourage communication with different audiences. With the adjustment of settings, content can be delivered within the classroom or to the general public. A variety of platforms are available with different levels of support.

The potential benefits students acquire by creating their ePortfolios extend beyond their academic careers. In practicing the higher-order cognitive skills of synthesis and evaluation, they are enhancing their civic and scientific literacy so that when they graduate, they will have the tools to make informed decisions about personal science-based issues such as how to best protect themselves from potentially harmful bacteria in public restrooms, whether to become an early or a later adopter of self-driving cars, how microbes could be the solution for pollution problems, and how data can give insights into issues of social justice abroad and at home. Similarly, the skills that students acquired as they built their ePortfolios enhance their life-long, effective digital citizenship. When they graduate, they will be experienced at using digital tools to research the validity and credibility of media content available online and to communicate effectively their understanding on issues (e.g., childhood vaccinations, data protection, global warming) related to science and technology affecting themselves and their communities.

Limitations

As described earlier, more STEM programs are beginning to use ePortfolios in conjunction with other HIPs such as undergraduate research on authentic problems to encourage intentional learning and increase persistence in their majors. However, despite institutional support, implementation across programs may vary considerably with some departments and faculty using ePortfolios consistently and others not using them or using them irregularly and in limited ways only, which is the case at Eugene Lang. At other institutions where platforms have changed and the perceived learning curve for implementation is high, the initiative has come from individual faculty championing their use within their courses and programs while spearheading efforts for more widespread adoption, which is the case at Santa Clara University. However, even in less ideal situations, our STEM and English course pilots have shown that students can still benefit from even partial ePortfolio adoption.

Future Directions

We recognize that our work is not complete and there are many directions that we could take,

particularly in the area of assessment. While there are many effective VALUE rubrics, there is no clear choice for assessing civic and scientific literacy. Interdisciplinary assignments pose unique challenges when it comes to assessment. As much as we hate to admit it, our language and styles differ across the disciplines and something that might work well for the humanities will need to be adapted for other audiences. While we consider that the gold-standard for institutions would be to integrate ePortfolios throughout the curriculum, we recognize the challenges and barriers noted above. A good first step would be to integrate an ePortfolio assignment into at least one course, potentially in the first-year experience, and to attempt to integrate into others once students are familiar with their use. We plan on doing just that. At Eugene Lang, we plan to use ePortfolios in a new course, Building Your Career Ecosystem. This will represent the third implementation of ePortfolios in the department and will serve as a model for other STEM majors at the college. At Santa Clara University, we plan to use ePortfolios in several courses of our new neuroscience major and in all writing-intensive courses for our engineering majors.

Conclusion

Our paper has revealed the many different ways that ePortfolios can be leveraged to bridge the gaps between our disciplines and work synergistically with writing intensive courses to create connections between STEM and the humanities. From individual ePortfolio-based assignments and activities to semester-long PBL and degree-spanning work, we have shown how implementing ePortfolios throughout students' academic programs can ameliorate curricular fragmentation by encouraging students to reflect on connections between concepts and content inside and outside their major to maximize the benefits of HIPs such as first-year experiences, undergraduate research, and writing-intensive courses. Also, it is equally important to communicate that learning to a variety of different audiences. In this way, ePortfolios bring coherence and cohesion to students' studies and demonstrate the plethora and diversity of student learning in the digital age. Despite our disciplinary differences, we have shown how ePortfolios in science and English classes can be leveraged to connect classroom learning with issues of real-world importance. In the 21st century, the need for interdisciplinary and integrated thinking about the world and the problems we face is clearly evident to institutions and employers. Powerful ePortfolio-based pedagogy offers a venue that can adapt and flex to serve the needs of faculty and students alike while

expressing student learning in a public and accessible way and to multiple audiences.

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