

# ePortfolios to Promote Equity, Engaged Learning, and Professional Identity Development in STEM

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**Abstract:** ePortfolios are considered the eleventh high-impact practice (HIP) by the AAC&U (now the American Association of Colleges and Universities). They have been widely implemented in the humanities but remain underutilized in STEM fields. The benefits of engaged learning, metacognitive awareness, and professional identity development in those programs that use them suggest that students who are not exposed to them are missing out on a valuable pedagogical practice. Participating in multiple HIPs, and even combining them, has been shown to benefit students, particularly those who are first-generation, low-income, minority, and members of other traditionally underrepresented student populations likely to switch out of STEM into other disciplines and whose college attrition rates are higher. We demonstrate the affordances of ePortfolios for promoting equity, engaged learning and professional identity development in STEM. Drawing on published research, our own and others, we show how ePortfolios in the context of inclusive teaching practices can ameliorate some of the causes of attrition or lack of engagement of underrepresented minorities in STEM fields. We conclude with a research agenda to encourage further study into the potential affordances of ePortfolios for promoting engaged learning and professional identity development in STEM.

ePortfolios became the eleventh high-impact practice (HIP) in 2016 when the AAC&U (now the American Association of Colleges and Universities) added them to the existing list of HIPs (Watson et al., 2016), a set of effective pedagogical practices across the curriculum. Participating in multiple HIPs—and, better yet, combining them—has been shown to be beneficial for students (Batson et al., 2017; Eynon & Gambino, 2017; Reynolds et al., 2014), especially those who are first-generation, low-income, minority, and members of other traditionally underrepresented student populations (Finley & McNair, 2013; Kuh, 2008). However, although HIPs have been widely implemented across the curriculum, some HIPs, such as ePortfolios, are less common in STEM courses. This is unfortunate because STEM programs tend to have higher student attrition rates than the humanities, especially among first-generation, low-income, female, and other minority student populations (Sithole et al., 2017) and a growing body of evidence both from researchers and practitioners suggests that ePortfolio pedagogy could help (Eynon & Gambino, 2017; Singer-Freeman & Bastone, 2017; Singer-Freeman, Bastone & Skrivanek, 2014; Smyth, Chen, Sompanya, Metz & Conefrey, 2022). We suggest that ePortfolios, when done well, are an under-utilized resource for increasing retention and promoting diversity, equity, and inclusion in STEM. After taking stock of some of the factors related to the field's lack of diversity and equity, we explore examples of how ePortfolio pedagogy in STEM

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could help, discuss the limitations of current studies, and propose an agenda for increased ePortfolio implementation and research across STEM curricula.

## Why We Should Care About Increasing Retention Rates in STEM

Attrition from STEM fields contributes to the so-called leaky pipeline and leads to a significant gap between employers' needs and job seekers' skills (Okrent & Burke, 2021). Despite increased efforts to reduce inequities and increase diversity in STEM education and STEM careers, slow progress is being made. According to a 2021 Pew Research Center report, ethnic minority workers remain underrepresented in STEM careers compared with their share of all workers (Fry et al., 2021). Hispanic workers, for example, who occupy 17% of all positions represent only 8% of STEM occupations. Similarly, women remain underrepresented in all STEM occupations where they hold about a quarter of the positions. Fry and colleagues note, "While the nation's colleges and universities have increased the number of degrees awarded in STEM fields, there is little indication that the flow of degree recipients will dramatically increase gender, racial and ethnic representation in related job areas over the near term" (2021).

Diversity in STEM undergraduate and graduate student populations is not simply a matter of equity but also of scientific progress because diversity encourages more novel solutions and discoveries (Wiedemann, 2019). Today's complex, capacious problems require fresh perspectives from various cultural backgrounds. Problems like climate change, world hunger, data privacy, and cyber-attacks require creative thinkers and problem solvers, who can bring much-needed innovations to their fields. Acknowledging the importance of diversity, the latest strategic plan (2021–2026) for the National Research Council of the National Academies of Science, Engineering, and Medicine counts among its four tenets a design for diversity, equity, and inclusion (NRC Strategic Planning Committee, 2021). Fortunately, there is an increasing recognition that to make STEM programs equitable, they must acknowledge and address the disadvantages that some students face. It is not enough to provide academic knowledge, STEM programs must also be designed with equity and diversity at the core (Kezar, 2021).

## Exploration of the Chilly Climate in STEM For Underrepresented Minority Students

The reasons for the leaky pipeline and lack of diversity in STEM are complex. Drawing on paradigms from critical race theory (CRT), feminist theory, and intersectionality, scholars have identified patterns of systemic discrimination and racial inequality in education (Crenshaw, 1989; Ladson-Billings, 1998). Such scholarship has led to increased support for more equity in education and calls for teaching approaches to identify and eliminate barriers that discourage equitable participation of underrepresented student populations, such as underfunding in certain school districts and rising educational costs. Internal factors impacting students' success, while harder to identify and quantify than the more tangible ones, can coalesce into what has become known as a "chilly climate," a hostile or unwelcoming atmosphere, which can lead to a lack of connection to the program or college (Spencer et al., 1999). This lack of a sense of belonging can lead to negative consequences for students' well-being and their intellectual achievement. If instead of feeling part of the class community, students come to believe that members of their racial, ethnic, and gender groups do not perform as well as students from the majority group, they may unwittingly reinforce such stereotypes and suffer what has come to be known as stereotype threat. For example, if gender is mentioned as negatively impacting math test scores, women might perform poorly and perpetuate the stereotype that women are not as good as men at mathematics (Spencer et al., 1999). In other words, systemic forces may collude to constrain the ability of minority students to be successful.

Another such factor is implicit bias, or unexamined beliefs that are difficult to challenge and change without first being recognized and acknowledged. Instructors may believe that women are inherently less suited to STEM fields, that students who enter with lower GPAs cannot catch up, and that abilities are fixed (Dweck, 2006) rather than malleable, that students who perform poorly in early exams will likely do the same in later ones. Such unchallenged biases can also lead to microaggressions, that is, statements, actions, or incidents that are forms of indirect or subtle discrimination against members of marginalized groups (Sue et al., 2019). Unfortunately, the subtlety of such sleights and the internal nature of the other factors make them difficult to identify and address often for both the offender and those who experience them (David, 2014) and may lead students to develop imposter phenomenon, a feeling that one does not belong in their program or college, which, in turn, can lead to a lack of confidence in one's ability to succeed (Cisco, 2020) as students may end up wasting energy monitoring their environment for threats rather than using their cognitive resources for learning (Lalain, 2016). Although some believe that implicit bias and microaggressions are less prevalent in STEM classrooms due to the objective nature of the content, the research of Collin Harrison and Kimberly D. Tanner (2018) suggests that different forms of microaggression can impact students' sense of belonging, self-efficacy, and their ability to develop an identity in science. Similarly, Heather M. Falconer's (2022) in-depth case study of underrepresented students' experiences in STEM programs discusses the challenges described above and how students attempted to negotiate them to succeed in their chosen majors.

## Inclusive Teaching Practices for Implementing ePortfolios to Promote Equity and Engaged Learning

While many of these external factors that lead to a lack of diversity are still prevalent, most colleges now have offices and services dedicated to increasing diversity and inclusion. For example, the Office for Diversity and Inclusion at Santa Clara University “supports the recruitment, retention, and success of a diverse university community—encouraging collaboration, academic excellence, and a diverse, inclusive campus climate” (*Office for Diversity and Inclusion - Santa Clara University*). With the establishment of offices to promote diversity, equity, and inclusion comes more awareness of factors leading to a chilly climate, bias, and microaggressions and the promotion of more inclusive teaching practices to resist these forces. Acknowledging the potentially higher attrition rates of underrepresented students in STEM, we advocate inclusive, engaging teaching practices to create an equitable, accessible, and rigorous learning environment for all students. Based on the numerous ACUE (Association of College University Educators), NABT (National Association of Biology Teachers), Association of American Colleges and Universities (AACU), SENCER (Science Education for New Civic Engagements and Responsibilities) and other pedagogy-focused workshops and programs at our institutions that we have participated in over the years, we have developed the following guidelines to design our courses and create student-centered learning environments:

1. **Build a classroom community** that provides a supportive learning environment where students feel seen, heard, and respected.
2. **Address threats** to effective learning such as implicit bias, imposter syndrome, micro-aggressions, and other threats to the learning environment.
3. **Promote self-efficacy, self-regulation,** and *cura personalis* to lead to well-being/flourishing.
4. **Design the course for equitable learning** by checking that course materials support accessibility technologies, reflect perspectives from a variety of scholars

(including marginalized voices), and use inclusive language so that underrepresented minorities see themselves in course materials.

5. **Make assignments transparent and authentic** by matching assignments to the learning objectives and including formative as well as summative assessments.

We operationalize these guidelines by inviting students to co-develop guidelines for classroom interactions and assignment rubrics. We consider the social characteristics of the make-up of our classes (ethnicity, gender, ability, socio-economic status, first-generation status, immigration status, and so on) and we try to increase our awareness of implicit bias, privilege, imposter syndrome, and microaggressions. We explicitly promote students' confidence in their learning abilities by augmenting their study skills because, as Tinto noted, "self-efficacy is the foundation upon which student persistence is built" (Tinto, 2017, p. 257). Following from the pioneering work of Albert Bandura and the National Institute of Mental Health (1986), we view the relationship between self-efficacy and self-regulation as bidirectional. High levels of self-efficacy, self-regulated learning, and metacognition mutually support one another leading to increased confidence and higher grades. We also believe that by engaging with our students as whole persons rather than embodied brains and using a variety of techniques such as lectures, discussion, group work, and problem-based learning, we can encourage more active student participation and learning. Inclusive syllabus design principles such as checking the tone, making sure that assignments are scaffolded and transparent, offering a variety of assignments and assessments (formative and summative), and ensuring that they are aligned with the course learning objectives are also strategies that we use to ensure that our courses are welcoming to students. Inclusive teaching is at the heart of our practice as educators and foundational to every class we teach because of our commitment to student success. Working at different institutions and in different disciplines, this commitment has led to our advocacy of ePortfolio pedagogy for promoting equity, identity and engaged learning.

While not suggesting that ePortfolios can ameliorate all the issues identified earlier, we believe that in conjunction with other HIPs such as first-year seminars, capstone courses and projects, writing-intensive courses, and undergraduate research, they can be particularly helpful for enhancing learning in a wide variety of institution types and for all student populations, particularly those that are disadvantaged (Conefrey, 2017; Finley & McNair, 2013; Hubert et al., 2015; Kuh, 2008; Tukibayeva & Gonyea, 2014; Watson et al., 2016); HIPs appear to work synergistically and their benefits are thought to be cumulative (Hubert et al., 2015; Kuh et al., 2013; Tukibayeva & Gonyea, 2014; Watson et al., 2016). HIPs align well with the goals of science education organizations such as SENCER (Science Education for New Civic Engagements and Responsibilities), which recommends connecting engaging students by connecting basic science to authentic unsolved problems and helping students understand the relevance of science in their daily lives. Participation in HIPs also aligns with KEEN (Kern Entrepreneurial Engineering Network) a national organization focused on increasing student engagement in engineering majors. Although ePortfolio implementation, even in the humanities, is still uncommon at many institutions, there are many resources to support faculty interested in integrating ePortfolio pedagogy into their courses across the curriculum. National associations include AAEEBL (Association of Authentic, Experiential, and Evidence-Based Learning) and AAC&U as well as international associations such as ePortfolio Ireland and ePortfolios Australia. Other useful 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. There are also comprehensive guides that can serve as a foundation for implementation from leaders in the field (Batson et al., 2017; Eynon & Gambino, 2017, 2018; Penny Light et al., 2011; Reynolds et al., 2014).

## Values Framework for Evaluating ePortfolios in STEM

We are staunch advocates of ePortfolios, in particular because they connect and reinforce other HIPs (Conefrey, 2017; Conefrey & Smyth 2020, 2021). In announcing the addition of ePortfolios to the list of HIPs, C. Edward Watson et al. (2016) note that ePortfolios can amplify the impact of other HIPs that students participate in, acting as a meta-HIP. However, ePortfolios must be done well to be effective. Watson et al. caution, “HIPs are not HIPs because they carry the label but because, when done well, and with considered thought and implementation, they lead to deeper student learning” (2016, p. 66). To explore what ePortfolios done well might look like, we draw on the work of Bret Eynon and Laura M. Gambino (2018). Their catalyst for learning framework is based on the experience of 24 campus teams collaborating for four years across the United States on connect to learning (C2L), a project funded through a FIPSE grant. After analyzing data from these wide-ranging institutions and programs, they made the following observations, which they called value propositions (Eynon & Gambino, 2018 , p. 9):

1. ePortfolio practice done well advances student success.
2. Making learning visible, ePortfolio practice done well supports reflection, integration, and deep learning.
3. ePortfolio practice done well catalyzes learning-centered institutional change.

They noted that ePortfolio programs aligned with other student success indicators, like higher pass rates on exams, higher end-of-semester pass rates, higher GPAs, and higher retention and degree completion rates. As evidence of reflection, integration, and deep learning, they included both qualitative and quantitative data from a survey that they developed to gain insight into the student experience of ePortfolio usage. Students commented on the benefits of the reflection process in helping them see connections across courses and extracurricular activities, increasing their openness to learning, and supporting a better understanding of themselves and their future goals. What students found particularly helpful was feedback from their instructors and their peers, which Eynon and Gambino note helped lead to improvements “not only in completion but also quality, advancing and supporting higher order thinking and integrative personal growth” (2018, p. 181). As evidence of campus-wide institutional change prompted by ePortfolio implementation, they include collaboration across disciplines and increased faculty development opportunities, leading to shared conversations across campus about student learning.

## Using the Values Framework to Describe ePortfolios “Done Well” in STEM

Eynon and Gambino’s catalyst framework (2018) offers a valuable guide for implementing ePortfolios in STEM because the authors carried out much of their research in many different programs at a wide variety of institutions, including community colleges and minority serving institutions. We view the three value propositions that they identified as an effective framework for evaluating ePortfolio implementations in all programs including STEM because although the C2L project did not focus explicitly on STEM, Eynon and Gambino note that the intervention led to more graduates deciding to pursue careers in STEM fields or enroll in advanced degrees in STEM disciplines (2018, p.165–169). Evidence of successful STEM ePortfolio implementation which aligns with the C2L value propositions comes from their multi-year use at the University of New South Wales in Sydney, Australia in multiple programs in the medical sciences. In reflecting on several different implementations over the years, Patsie Polly et al. (2020) describe how they designed their implementation with the goal of developing reflection, digital literacy, and professional development.

They note that the ePortfolios enabled students to “develop their professional identities as medical scientists while developing the necessary skills and capabilities to provide evidence as graduates of this program of their leadership, scholarship, global citizenship, and professionalism” (p. 127). As with the other HIPs, the focus in ePortfolio pedagogy on the whole student appears to help students understand who they are as learners and who they want to become. Polly et al. note that in learning to reflect, integrate their learning, and identify transferable skills, “students are able to recognize and build professional skills that underpin graduate attributes such as communication and teamwork” (p. 129).

The idea that ePortfolios might support retention in STEM is supported by a growing body of ePortfolio scholarship. For example, an intervention (Falco & Summers, 2019) that introduced girls to the concept of a growth mindset (Dweck, 2006) reported a positive impact on the girls’ STEM self-efficacy and a reduction in their STEM confidence gap. Similarly, Singer-Freeman and Bastone (2017) carried out a growth mindset intervention with community college students in a summer research program. They found that the impact was even greater when the intervention was combined with an ePortfolio assignment than with more conventional formats. They speculated that reflection is intensified by creating the ePortfolio and that the holistic view of learning encouraged by the ePortfolio further reinforces a growth mindset over a more fixed view of learning. A similar conclusion was reached in a first-year STEM course that used both digital and paper portfolios (Bowman et al., 2016). They noted that while students in all sections found the reflective aspect of the assignment valuable, those in the ePortfolios sections realized greater gains in the course and in setting goals for their majors and future careers. Possibly, this is because ePortfolios have an expansive and longitudinal capacity so that students can continue to work on them as they take further courses and participate in additional HIPs. In this way, they increase integrative and intentional learning (Conefrey & Smyth, 2020, 2021), help students clarify their goals, and develop career awareness, which, in turn, can strengthen students’ motivation to complete their degrees. In our examples above, students reflected in their ePortfolio how the research skills they had developed would help them in their careers as scientists and engineers (see Figure 4 and Figure 5).

An example, which also exemplifies the first and second value proposition from the values framework, includes an intervention to improve engagement and deliver formative assessment in a non-major introductory science course at a small urban community college, where the majority of those enrolled were students of color (Fuller, 2017). Although all students had access to a course ePortfolio, students in the control group responded to discussion questions on course lectures by submitting their work in class, whereas students in the experimental group submitted their responses in their ePortfolios and received feedback there from the course instructor. Additionally, they were required to respond to extra low-stakes assignments and to comment on each other’s responses. This intervention was carried out in response to the challenge of general education science courses for non-majors, who often perceive science as difficult and fail to see the relevance of these courses for their majors. It also responded to prior assessment methods, which tended to rely on summative methods in the absence of meaningful ongoing formative assessment. Students in the experimental group, who created course ePortfolios, interacted more with the course materials and the course instructors and obtained higher course grades. The formative assessments from course instructors who viewed student ePortfolios also led to more instructors’ contact with students outside class time and in turn more student engagement in the course. Speculating on possible explanations for these improvements, Karla 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” (p. 444).

Another study on ePortfolios in college sciences courses comes from a cell biology course at the Universitas PGRI Madiun in Indonesia (Lukitasari et al., 2020), which explored how students of differing abilities might respond to an ePortfolio intervention. After being familiarized with the technological aspects of ePortfolios, students worked on a variety of course-related materials individually and in groups, which they uploaded to their ePortfolios. Students' knowledge of the course content was evaluated using learning outcomes tests and their attitude to the implementation of ePortfolios was explored using a 20-item Likert-scale questionnaire. Students who started with higher levels of ability fared better in the outcomes test than those with lower levels of ability; however, both groups responded positively to the ePortfolio intervention. In general, the researchers concluded that the ePortfolio had a beneficial impact on student learning. They noted that weaker students used the reflective and collaborative aspects of the ePortfolio to review gaps or mistakes in their understanding and were more likely to redo work. Instructors viewing student work also found it helpful to understand which concepts students had the most difficulty understanding and valued the ease with which they could offer feedback in the students' ePortfolios.

## Findings from ePortfolio Implementation at Our Institutions

The examples from our own institutions identified similar benefits to those found at the other institutions noted above, including integration of knowledge, improvements in self-efficacy, and the development of an academic or professional identity. While ePortfolio use in STEM classes remains underdeveloped, we and our colleagues have integrated ePortfolios into a variety of courses at different levels across the curriculum, as they can be tailored to different student ability levels or developmental stages. With approval of our Institutional Review Boards and permission from students and colleagues, we present examples from our ongoing studies and previous studies to illustrate how Eynon and Gambino's (2018) value propositions and inclusive teaching practices can be put into practice in different types of courses and assignments. The findings that we report have been generated from a variety of courses, in different programs and at different institutions using mixed methods approaches (mostly qualitative) and with different measures of success such as students' perceptions of learning gains, increases in student retention, and higher course grades. As other ePortfolio researchers have noted, ePortfolio interventions are rarely designed as randomized controlled studies for obvious reasons, such as the difficulty in controlling numerous variables and financial constraints. Instead, data processes and analysis are shaped by local conditions, institutional constraints, goals, and student needs. Although all our ePortfolio interventions suggest positive outcomes as with much of ePortfolio research, definitive proof of causality is lacking (Bryant & Chittum, 2013). However, as our main goal is to encourage increased ePortfolio implementation in STEM fields, we hope that our pragmatic validity (Blakeslee et al., 1996) will suffice to spur further study.

### First-Year Seminar: How the Toilet Changed the World

Our first example of an ePortfolio done well, which exemplifies the first two value propositions of the value framework, comes from a first-year seminar at Eugene Lang College, a Liberal Arts college that hosts approximately 1500 undergraduates and is a member of the New School, a private university in New York. How the Toilet Changed the World uses inclusive teaching practices and is coupled with other HIPs that students are exposed to during their first year of college. It tackled 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. This writing-intensive course featured simple lab experiments to help students engage with civic issues and problems of real-world import. Using (the kind of learning strategy promoted by SENCER) project-based learning framework, the students embarked on a semester-long collaborative project that involved designing a more sustainable, culturally sensitive,

aesthetically pleasing, and affordable toilet that promoted integration of classroom learning with research outside the classroom to develop a single prototype of the design. This course featured inclusive teaching practices such as the co-creation of a classroom community agreement via Padlet with students ranking what they considered to be important for an inclusive and comfortable learning environment. Students used their ePortfolios to reflect on their experience each week and to integrate their prior knowledge with their classroom learning, while also tackling the civic issues of the class. Students were also encouraged to comment on each other's work and to communicate with their peers and the New School community via their ePortfolio. The assignment prompt for the first ePortfolio entry states the following:

Why are you taking this course (be honest) and what do you hope to get from it? What do you know about toilets? What would you like to know? Is the course what you expected? Why or why not? Was there anything that surprised you in the first day of the course, or something that got you excited, upset, concerned, curious? How will you balance this course with all others? What connections can you make to the other courses you are taking or have taken?

Prompts were designed to elicit authentic responses and to encourage collaboration to help students reflect on how they learn, connect to, integrate, and value the course content, and to see the relevance of this course to others they are taking.

The aim was to set the foundation for reflection and to promote deep and integrative learning. Using the ePortfolio provided the instructor with a pulse on student learning and their reflective process as they journeyed through their first semester in college. The student's experience was positive and demonstrated the breadth of topics that the student had engaged with as evidence of deep and integrative learning (value proposition 2).

In my first post, I was eager to learn more about toilets, as I knew very little about them. The only thing I did know was what I had learned during Professor Smith's introductory lecture about toilets and the course, as I mentioned in the post that there are 2.4 billion people who still don't have access to toilets. After we watched the documentary about toilets, I soon learned the why behind my ignorance: since toilets have assumed a taboo status in society, toilets are not often discussed. As a result, people including myself, don't have much knowledge of them. Albeit professor Smith's father was a plumber, so she's the exception to this! At the inception of the course, I thought that only people in developing countries did not have access to sanitation, and that everyone in developed countries such as the US had adequate, if not excellent, sanitation. I now understand that there are populations within the US that don't have access to toilets. Analyzing the data on the rates of toilet access strengthened my understanding of this, as I found that the West has the lowest average rate of toilet access, and that Alaska has the lowest rate of toilet access. After reading that week's articles and listening to Professor Smith's lecture I even learned that the Skid Row homeless populations access to toilets does not meet the United Nations standard for refugee camps. This rattled me allowed me to understand that inadequate sanitation is a problem not only limited to developing countries. Similarly, it was shocking to learn that the Tomoka correctional institution in Florida only allows inmates one roll of toilet paper every 10 days, and that they don't distribute rolls when inmates run out even though they have a stockpile of toilet paper in the supply closet adjacent to the cells. The video about the subpar condition of public bathrooms in Boston allowed me to draw a connection between the abysmal state of public toilets and the treatment of toilets as a faux pas. Our public toilets reflect our population's

proclivity to shy away from discourse about toilets. I also learned more about the history of cholera outbreaks and Jon snow's discoveries regarding the relationship between contaminated water and the spread of disease. I also learned more about the connection between cholera and open defecation. I was saddened to learn that open defecation not only contaminates water supplies, and as a result, food supplies, but that it raises safety concerns, as many women and girls are attacked when they defecate in the open. It was especially interesting to learn about the many cultures around the world, and the different types of toilets as well as the different ways of wiping before taking this course I was mainly accustomed to the western toilet, so the virtual tour of toilets around the world was especially beneficial in enhancing my understanding of the squat toilet. (student response sample)

This type of learning is not readily captured by traditional assessment measures, such as exams. It is clear from the reflection that the student was able to connect classroom learning with real-world experience and develop an awareness of multiple perspectives related to equity and inclusion (toilet paper access in prisons, safety of women and girls, inadequate sanitation for homeless populations). Posts from an international student's first reflection and their final reflection reveal the development of a sense of community and camaraderie among the students during the semester despite the transition to online teaching because of the COVID pandemic

My friend asked me, so what seminar are you taking? Me, answering, it's the seminar about toilets and poop. Japan. The country with a big obsession in making the most fantastic toilet satisfying everybody the minute they entered. Ever since I was born. I felt like I had some connection with the bathroom. Grew up as a weirdo. Love talking about poop and pee in public and could stay in the bathroom for hours and hours. At the same time, I firmly believe that excretion is essential to living a healthy life. Sadly, I am enthusiastic about toilets, however I am ignorant in the deeper level, history, the mechanism, problems, etcetera. That's why I have countless reasons to take this class to observe the topic in the academic field seriously. The first week was full of surprises and shocking moments. How they used to poop in centuries long ago made me appreciate it was born in this generation. Yet, I know that nothing has occurred only yesterday. Everything was invented from scratch and developed to have the design that we know today. So, thanks to the genius back then. Also, today's sanitation obstacles that many people face today made me feel I am privileged to have a clean bathroom and can take time to finish my business. This course is the most realistic topic. Learn to make tomorrow better for the others. (Student, First Post, September 7<sup>th</sup>, 2020)

Finally, I want to say how the whole class was and how much I liked it because of the people. I was so nervous since the topic was quite questionable and could create weirdness among the discussion, but none were true. Our class was one of the best classes I have ever taken so far. I had a time difference conflict so, so that I couldn't join some sessions, but I never felt left out. It's because our professor was the best, our classmates were the best and the topic was the best because it made us have a relaxed mood. I don't know how many times I should say thank you, and for sure, I will be missing this class and our space to talk about poop would a feeling the "it's gross" tension from outside!! (Student, Last Post, December 11<sup>th</sup>, 2020)

This sense of community and sense of belonging were particularly important when teaching moved online and many students struggled with mental health issues, which increased their risk of not

being able to complete their courses successfully. Increased belonging is a measure of student success (value proposition 1).

Figure 1 below shows a concept map that was displayed on a student's ePortfolio. In this way, the student was able to make their learning visible in multiple dimensions. This concept map illustrates how the student drew connections between toilets and a variety of social issues. This allowed the student to engage with real-world issues of importance and to connect across the disciplines beyond the science content being presented. These examples demonstrate how ePortfolios make learning visible (value proposition 2). These ePortfolios are done well, exhibiting student reflection, integration, and deep learning.

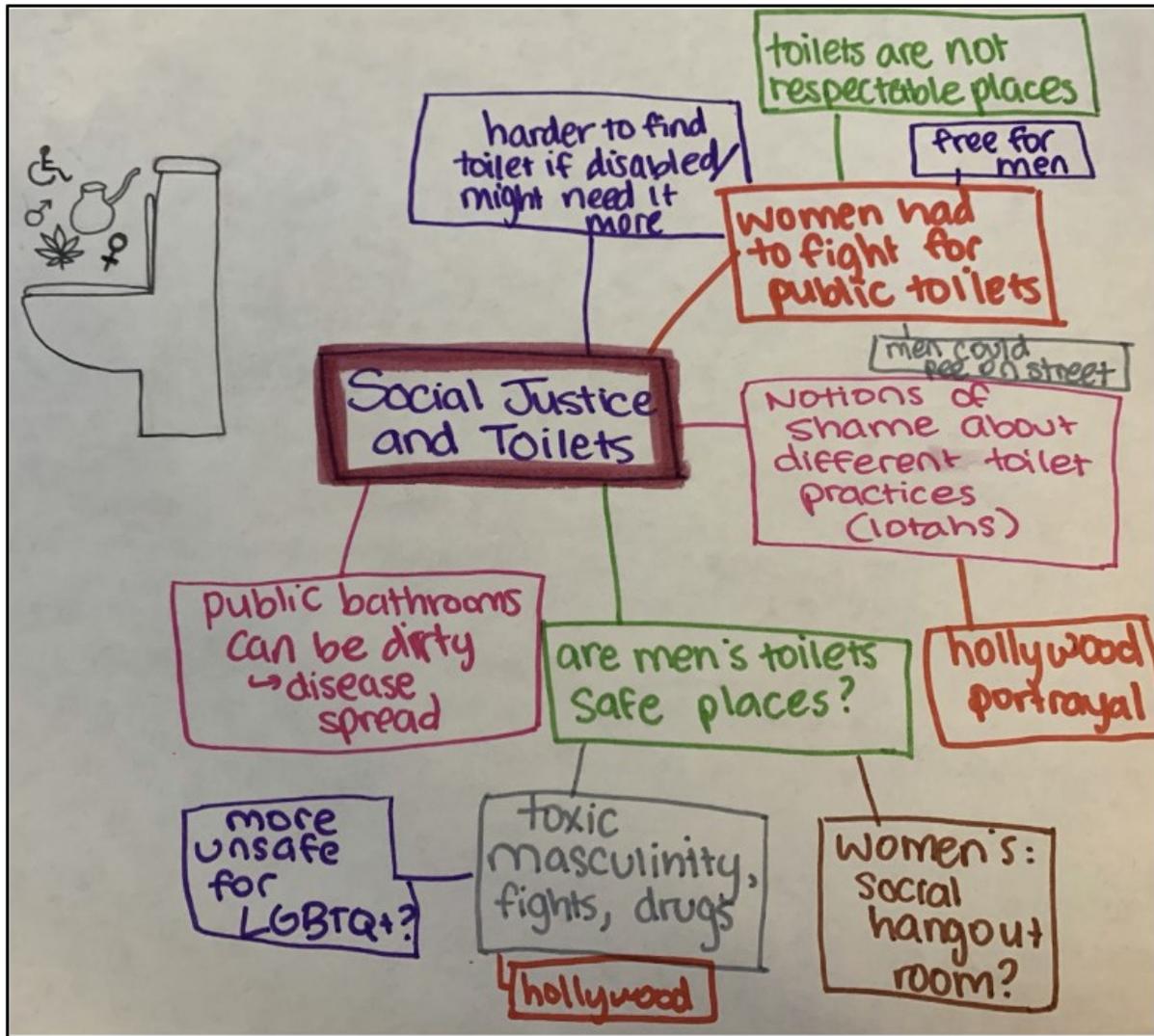


Figure 1: Social justice and toilets concept map

In order to evaluate how students perceived their own learning we used the student assessment of learning gains instrument at the start and end of the first-year course. The Student Assessment of their Learning Gains (SALG) is a free, adjustable course-evaluation tool that measures the degree to which a course helps students reach a course's student learning outcomes. Table 1 shows student responses (n=7) to the student assessment of learning gains (SALG) survey at the end of the course in Fall 2018 and Fall 2020. Student perceptions of the in-class activities revealed that variation in

how much they found each of the activities helpful, with students noting that the ePortfolio activity was of great help (15% in Fall 2018 when classes were in-person and 25% in 2020 when they were online due to COVID). Mean responses and standard deviations are shown. The scale used was 1: no help, 2: a little help, 3: moderate help, 4: much help, and 5: great help.

**Table 1: Student Assessment of Learning Gains**

How much did each of the following aspects of the class help your learning?	Fall 2018 (n=7 respondents)		Fall 2020 (n=7 respondents)	
	Mean	Standard Deviation	Mean	Standard Deviation
Graded assignments (overall) in this class	4	0.82	4	0.82
ePortfolios	3.7	1.38	4.3	0.95
Project presentation/slides	4.7	0.49	4.4	0.79
Project paper draft	4.6	0.53	4.1	1.07
The fit between class content and experiments we did (biodigester, poop experiments)	4.9	0.38	3	1.63
The mental stretch required by the science part/research	4.6	0.79	3.7	1.11
The feedback on my work received after assignments or experiments	4.9	0.38	3.9	1.07

### **ePortfolios in a First-Year Writing Course for STEM Majors**

Our next example, which exemplifies the first two value propositions of the value framework, is from a first-year composition for engineering students at Santa Clara University, a mid-sized liberal arts college in California's Bay Area. Engineering students from different majors were asked to create an ePortfolio to reflect on and showcase their writing skills and to discuss their transition from high school to college writing, how their writing style had changed, and how accurate or otherwise their expectations were for college writing. The goals of the ePortfolio were to help students demonstrate their learning to themselves and others and to make a successful transition from a high school to a college identity. Students were told that they should view the ePortfolio as a living site where they could continue to collect artifacts in other courses to showcase their college learning and become more intentional about their future careers. As we demonstrate below, many first-year STEM students resent required writing courses; therefore, another goal was to help them understand the benefits of writing and the value of effective communication skills. The assignment description for students' ePortfolios is listed below:

Create an **ePortfolio with a Reflection Essay (2-3 pages)** for this course, which you will continue to use next quarter:

Here is what to include:

1. A "**Welcome**" page explaining the purpose of the website (for example, to showcase your writing skills in an English course).
2. An "**About Me**" page describing who you are (your major, your career plans, what you hope to gain from your time at SCU, your hometown, your hobbies and interests, and so on).
3. A **Reflection** Essay, where you comment on what you have learned in this class. Here are some questions to help you generate ideas: What do you know now about writing and critical thinking that you didn't before taking the course? How have your thoughts on writing changed? How does what you have learned in this course relate to other classes that you are taking at Santa Clara University, your major, or your life in general? How have your reading, writing, and study habits changed at college?

For each point, you make, **provide evidence** and support from your own writing, reading, or class discussions by either uploading to the ePortfolio the assignments that you are discussing or quoting the relevant part of them in your reflection essay.

(You may use any of these questions that you find useful, but **you are not required** to respond to all of them. Pick and choose what speaks to you!)

**Photos and other visuals** supporting your text can also be included and will add interest to your ePortfolio.

You may choose any platform for your ePortfolio as long as you include the required sections. Pay attention to the **design and navigation** of your website and, before submission, check that all links are functional and that the permissions are set correctly. (Remember that **if I can not view your work, I can not grade it**. Send your ePortfolio to family and friends to check that it can be opened and viewed!)

(The goal of this assignment is to practice the learning outcomes 1.2, and 1.4. In addition, the reflection assignment will also help you review and consolidate your learning in this course. If you do your reflection carefully, it will help you understand how you have changed from being a high school graduate to a college student with an exciting future ahead!)

In their "About Me" pages, most students mentioned their desire to pursue a career in a particular field of computer science and engineering. Some named professional societies that they belonged to, and others shared what had drawn them to a particular branch of engineering. As part of the introduction to their reflection essays, many students mentioned their initial disgruntlement after learning that they were required to take a two-course English sequence. The safe classroom environment enabled one student to mention his fear that "the class was going to be a filler course, made to fulfill some basic education requirements," and another student to write: "Our CTW class focused on food and sustainability, which as a student studying bioengineering didn't appeal to me at first. I immediately began questioning how this would help me in my future." However, as the quarter progressed, the transparent assignment design and reflections helped students understand that the transferable skills they were learning could be useful to them in their other courses. For example, a Hispanic Male computer science major wrote:

My energy towards this class was negative from the beginning. As the quarter went on, I gradually forgot about the negative things that plagued me at the beginning...I think the most important and probably impactful thing I've learned in this class so far is how to find and use credible sources and information.

Other students could anticipate having to document their work and communicate with a wide variety of different audiences and felt that the course had prepared them well for this. This is evidence of increased student self-efficacy which is tied to student success (value proposition 1). One Hispanic female student noted:

As a bioengineering major aiming towards helping improve human health, it is integral that I am able to conduct research and convey my findings to other engineers through succinct, understandable writing. This class gave me a chance to step into the world of engaging in research at the college level and showed me how to use my writing as a way to critically analyze any topic I come across while developing insightful ideas of my own.

More evidence of student development of transferable critical thinking and writing skills necessary for student success is apparent in the final drafts of their Welcome pages. In his reflection, this mechanical engineering major describes his recognition that the skills that he is learning in his first-year writing class are transferable. Although he is unlikely to write research papers on food and sustainability in his mechanical engineering courses, he recognizes that he will be required to research engineering topics from a variety of sources and perspectives and to synthesize his findings in a cohesive and coherent manner. In this way, student ePortfolios promote student success in the course because they provide a space for students to reflect on their original thoughts about the course content and the skills that they are learning throughout the course and how those skills might be useful to them in other courses and in their careers. This aligns with value propositions 1 and 2, supporting student success and promoting reflection, integration of knowledge, and deep learning.

Both research and classroom practice suggest (as indicated in value propositions 1 and 2) that reflection improves knowledge transfer, critical thinking, and metacognition. One of the earliest educators to identify the value of reflection in the learning process was John Dewey (1933), who described it as an active, goal-driven process of making sense of experience and connecting old and new experiences with each other to create novel insights and drive future behavior. Carol Rodgers (2002), who developed Dewey's ideas further stresses the importance of reflection for helping students make connections across learning experiences and that this integration of learning is enhanced in receptive communities. Reflection also appears to improve students' metacognitive awareness, which in turn increases their perception of self-efficacy (Bandura, 1986, 1997). This speculation is corroborated by a more recent study by Callahan and Belcheir (2017), which found that a high grade in first-year composition courses was positively correlated with persistence across all majors, including STEM fields. They also noted that the actual grade was more significant than the level of the course taken so that obtaining an A in a remedial class was valued more highly than a B in a more advanced course. Self-efficacy and self-regulation have also been shown to impact grades in first-year mathematics courses (Altun & Erden, 2013) and biology across all years in college (Ridlo & Lutfiya, 2017). Bandura's research has been elaborated and expanded to account for success in engineering programs (Lent et al., 2013, 2015) and STEM fields in general. Reflection, which is at the heart of ePortfolio pedagogy, is central to self-appraisals of present and future efficacy in and across courses, as well as in and across HIPs.



Figure 2: The welcome page of a mechanical engineering major

## ePortfolios in an Undergraduate Neurobiology Course for Upper-Division Biology and Bioengineering majors

Another example of ePortfolios at Santa Clara University, which illustrates the second value proposition, comes from upper-division neurobiology. As a final assignment, upper division biology and bioengineering majors, some of whom are on pre-med and pre-dentistry tracks, were tasked with submitting an ePortfolio on a topic of their choice from a neurological perspective. They were told to use their ePortfolios to showcase their learning on a topic related to neuroscience and to present it in such a way that it is accessible to a wide variety of different audiences. The assignment description is detailed and describes what students will learn and the steps they should follow. The overview (with permission from our colleague) is as follows:

**PURPOSE:** To develop strategies for exploring any topic in neuroscience that you are curious about from a neurobiological perspective. This includes using literature research strategies, making connections between different scholarly communications, and building time management skills. With the final project, you will demonstrate your ability to critically evaluate the scientific literature, integrate the new knowledge you acquire from your literary research into your understanding of a question in neurobiology, and communicate that understanding to your classmates and others interested in neuroscience.

**TASKS:** Your task with this project is to (1) identify a topic in neurobiology you wish to explore further, (2) design and execute a literature review research plan to identify

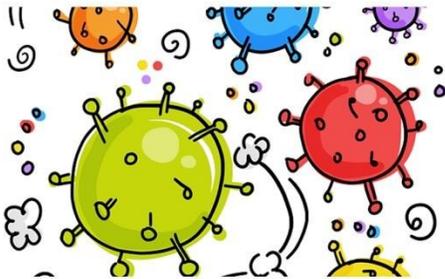
articles pertinent to your topic, (3) evaluate experimental data that has advanced scientific understanding of your topic, and (4) communicate your synthesis of the conclusions from a number of experimental perspectives.

In this assignment, students are given a list of what to include (an “About me” page, a review of their topic, a critical analysis with relevant graphics, an annotated bibliography, and a timeline for the project). Additionally, the grading criteria are explicit, there are opportunities to receive feedback and there are multiple options for succeeding in the course. This assignment has authentic assessment tasks that build research practice skills in written communication and help students learn how to integrate what they are learning in the classroom with what they learn from library research. Also helpful is the requirement that the research be presented to non-technical audiences since this makes the value of the research even more transparent to students and connects their work to everyday life. A similar assignment was given in a School of Medical Sciences research internship course at the University of New South Wales, where an oral research paper presentation and lab skills were also included (Polly et al., 2020). Such assignments help students transition from an academic identity to one that is more professional as they connect their major to their possible career.

### **ePortfolios in Microbiology and Virology Courses**

Following the values framework, ePortfolio implementations in microbiology and virology courses at one institution have been successfully iterated at several other institutions. Using tailored rubrics, student assessment of learning gain surveys, and end-of-course exam questions, we were able to demonstrate how an ePortfolio assignment could be used in microbiology courses taken by majors and nonmajors, allowing us to measure student learning outcomes in several courses as well as our progress toward program learning goals (Smyth et al., 2022). The assignment promoted engaged learning by encouraging students to reflect on their learning and place it in a real-world context by connecting science, microbiology, and microbes with issues of social importance like cholera, gender equity, and antibiotic resistance. Writing from a first-person perspective and drawing on resources obtained in class and from their own research, students generated profiles for a chosen microbe and documented the microbe in creative ways including creative works, such as an art piece or a poem that could highlight and showcase the microbe in a format that is accessible to the public to increase awareness of the role of microbes in ecosystems. At Texas A&M University-San Antonio (A&M-SA), we’re adapting this activity to help students engage with viruses and to draw connections to the social, political, and economic factors influencing healthcare outcomes in the context of virology. Again, these assignments are done well, allowing students to make learning visible and to demonstrate reflection, integration, and deep learning of class materials.

As a result of participating in multiple HIPs, students were able to build relationships with faculty, which improved their engagement and sense of belonging and academic engagement. In the case of the virology course, several students were encouraged to ask to join the instructor’s research group as they had not had research experiences before then. Three students from this cohort were successful in applying to master’s programs (one with the PI and two at a prestigious local institution). Though we have small numbers to pull from, we take evidence of students asking to participate in research and college life and successfully entering graduate programs as evidence of self-efficacy and increasing motivation to persist in STEM, all markers of student success (Gonzales et al., 2015; Hagerty et al., 1992; Katrevich & Arugete, 2017; Pratt et al., 2019; Tinto, 2017).



## Let's get to know some viruses with the class of Fall 2022

In this assignment the students are asked to design a site to show off their chosen virus - they've been given prompts and guidance - I'm excited to enter the world of viruses through the lens of our our Fall 2022 class...

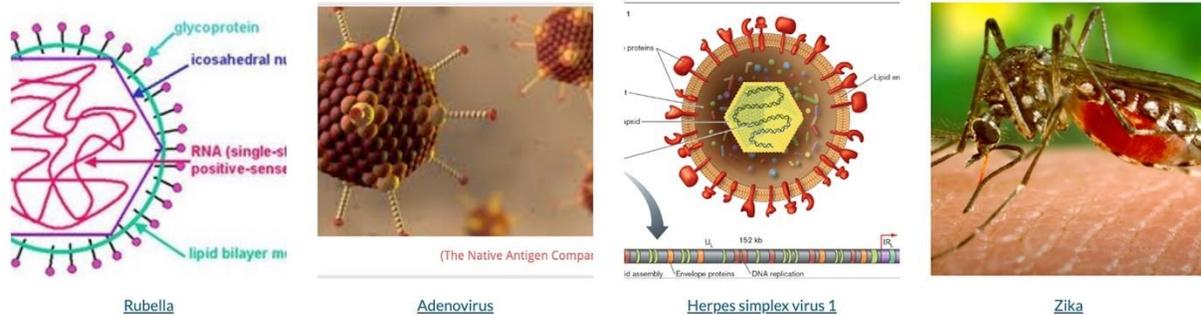


Figure 3: The class page showing a selection of the sites generated by students in the virology class

## ePortfolios in an Engineering Management Master's Course

The values framework also works well for ePortfolio implementation in graduate STEM courses. An example of ePortfolio implementation in a graduate engineering course comes from Effective Oral Technical Presentations, a one-quarter technical presentations course offered by Santa Clara's Graduate Engineering Management Program that exemplifies the first and second value propositions. As the culminating assignment for this course, students demonstrate their technical communication skills, both orally and in writing in their ePortfolios. The exact assignment details have varied over the years as the available platforms have changed. Initially, students were asked to create blogs about effective technical presentations but as platforms have become more sophisticated, they have been asked to include examples of their own technical presentations. In recent iterations of the course, students have been tasked with creating a "Welcome" and an "About Me" page and asked to upload samples of their oral (videos) and written work (PowerPoint slides) and to contextualize these artifacts. The EMGT 270 Assignment includes landing pages and revised presentations and asks students to do the following:

Create an ePortfolio to showcase your technical presentation skills. Here is what to include:

1. a “Welcome” page, telling the viewer what the website is about and its purpose, which is to show your technical communication skills, both orally and visually.
2. an “About Me” page with information about who you are, maybe including content from where you are from, your degree program, your career plans, what you hope to gain from your time at SCU, and your interest.
3. Upload at least two revised presentations, one of which should have sound (both could be videos, or you could have one video, and an audio presentation with project slides, or project slides by themselves). Introduce each presentation briefly, describing its purpose and what you hope the viewer will take away from it. As you decide which materials to include, consider your ePortfolio as a tool for presenting a professional identity, which you share with employers as evidence of your skills. Your ePortfolio can also be useful as you consider how you want to present yourself at interviews. Optional extras that can increase interest and engagement in your ePortfolio include photos and other graphics and your resume or a personal statement. (Note that none of these items are required.)

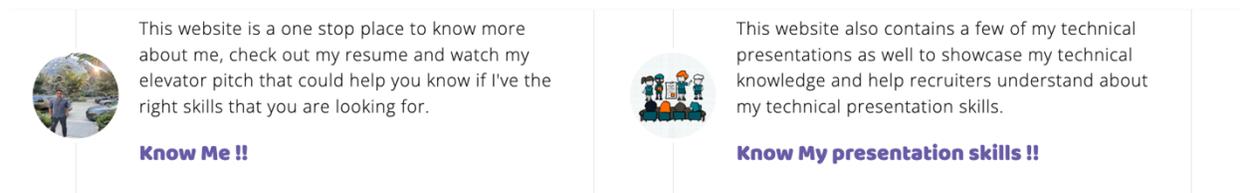
You may choose any platform you prefer for your ePortfolio so long as you include the required sections. Pay attention to the design and navigation of your website and, before submission, check that all links are functional and that the permissions are set correctly.

Students used the ePortfolio to promote a professional identity by including the required artifacts as well as resumes and links to their LinkedIn and GitHub sites. As was typical for this course, most were international students, and the remainder, mostly domestic underrepresented minority students, were undergraduates who were enrolled in the university’s five-year master’s program.

Figure 4 is an example from a computer science and engineering student that exemplifies the first and second value principle. In their “Welcome” and “About me” pages, students mentioned their passion for engineering and the skills and knowledge they had acquired from work experience and academic coursework. Some also mentioned hobbies, travel, and organizations that they belonged to. In addressing the assignment requirements, students used a variety of content on various ePortfolio platforms to showcase their technical communication skills including presentation slides, video presentations, voice-overs, and audio recordings. Rather than including a professional photograph, this student chose to represent himself with a graphic. Some minority students who fear discrimination based on their ethnicity may chose not to share head shots. As instructors, students often need our help to think through issues of representation.

Students demonstrated audience awareness by providing context for their work and indicating how their website could be navigated. For example, a bio-engineering student wrote:

This website is dedicated to showcasing my development in providing quality technical presentations. Navigate to the Projects page, where you can view the presentations, I created for this class. For each presentation assignment, you can view the initial presentation, then the next iteration that showcases an improvement in my skills. Navigate to the About Me page, where you can learn more about my personal and professional background (with fun facts of course!).



## About Me

I'm a student completing my Master's in Computer Science and Engineering at Santa Clara University. I will be graduating in December 2022 after which I will be join Amazon as a Software Development Engineer.

I have taken courses such as Data Mining, Machine Learning, Trust & Privacy Online Social Network and Algorithms. Having a GPA of 3.70+, I have proven my eligibility to learn and understand my coursework.

Currently, I am based out of sunny Santa Clara, California. Very soon about to move to not so sunny Seattle, Washington.

Ever since I was a kid, I have been interested in computers. I was always curious to learn about how computers work. We create new stuff every day as developers and that is what motivates me. In a sense, we are builders rather than engineers. Making anything from scratch is quite fulfilling.

Other than developing softwares, I play basketball and was a national level basketball player representing my state Uttar Pradesh. I love hiking and try to go on one every weekend. I love watching movies. One secret dream that I have, is opening a desert bar. Yes I've a sweet tooth.

*Figure 4: An example of an “About Me” page*

Using a variety of different layouts and formats, students used their ePortfolios to showcase skills that they had acquired in this class as well as in their other classes, connecting also to their GitHub and LinkedIn sites as well as other commercial websites that they had created. Some were more generally informative, whereas others were targeted toward potential employers. In all cases, students took care to demonstrate both their technical and their soft skills as they engaged in integrating material from the course and extracurricular activities to present themselves as knowledgeable professionals. Budwig (2013) suggests that students go through different stages of intellectual development requiring both learning about their field and learning how to participate in its disciplinary-specific practices. Drawing on research that distinguishes between “foreclosed” and “achieved” identity, the former refers to an identity that is fixed and the latter to one that is more malleable (Marcia et al., 1993). Singer-Freeman and Bastone (2014, 2016, 2017, 2019) used ePortfolios in their summer bridge programs for community college students hoping to transfer to four-year colleges. They note, “We have found that ePortfolios have helped students create a holistic representation of themselves that includes academic identity, future orientation, and a sense of belonging to a community of scholars” (2019, p. 511). Professional identity development is an important aspect of persistence in a major, particularly for minority students who might not have many STEM role models to draw on. Students who persist in STEM fields tend to be both better informed about and more committed to their chosen major. Exemplifying value proposition 1 and 2,

students who create ePortfolios develop more intentionality, are better able to integrate their learning across courses and strengthen their identities in their chosen fields, which in turn increases their likelihood of persisting.

### **ePortfolios in a Graduate Seminar Class**

The values framework also works well for ePortfolio implementation in newer programs, particularly those that will possibly result in learning centered institutional transformation (value proposition 3). At A&M-SA, a young, Hispanic-serving institution, we are actively developing its graduate programs as this is the first step towards the institutional goal of achieving R2 status, which requires the development of research and graduate programs. We have recently established programs in biology, water resources science, technology, and psychology. Students in the master's program in biology take a course called Graduate Scholarship Advising and as part of this course, we are currently piloting the use of ePortfolios. This course is structured around the materials generated by the Center for the Improvement of Mentored Experiences in Research (CIMER) program (<https://cimerproject.org/>) and we're adapting the materials to a predominantly minority student population. For this class, we are using a variety of technology and tools in addition to the ePortfolios to build community, self-efficacy, and STEM identity in a group of students who are predominantly first-generation and non-traditional, many of whom work full-time. They often lack developed career plans and when asked why they are in the program and what they plan to do next, cannot answer. This is a critical concern for student success as we want to ensure that our students are prepared and knowledgeable of their options. We use assignments and readings to promote the development of self-efficacy. We use role-play games to promote ethical behavior and responsible conduct of research. Readings and scenarios are used to reduce imposter syndrome and to provide awareness of strategies to cope with stereotype threat and implicit bias. At the beginning of the course, students are asked to complete the [Individual Development Plan](#) (IDP). IDPs are commonly used in industry to help employees define and pursue their career goals, and in 2003 the Federation of American Societies for Experimental Biology (FASEB) generated an IDP framework for postdoctoral fellows in the sciences which was further developed by AAAS/*Science* as well as experts from several universities. The tool asks students to complete exercises that help examine their skills, interests, and values and shows 20 scientific career paths with a prediction of which ones would best fit their skills and interests. In addition, students are asked to complete an Asset Map based on the [equity, diversity, and inclusion framework](#) developed by Worcester Polytechnic Institute. Asset mapping has been shown to improve equitable and effective teamwork by helping students to overcome stereotypes and to build their confidence while minimizing task assignment bias. Students fill out asset maps (we provide them with examples) and discuss their assets (backgrounds, experiences, interests) with their classmates.

Throughout the course we leverage technology. We promote community building through peer review using shared documents and folders via Google Docs, as well as Google Sites which are used for the ePortfolio generation (students can maintain these sites and "own" their sites after graduation). Students engage with the literature using collaborative annotation tools such as Hypothes.is and online citation systems that allow shared libraries (Zotero, Refworks). These practices are used throughout the course, several times, helping students hone their skills and comfort with the tools. Both the asset map and the IDP are revisited at the end of the semester and students are asked to reflect upon them on their ePortfolios. Figure 5 shows a screenshot of a student's asset map generated in the graduate course. This activity ties to our value propositions 1 and 2 in that it asks the student to reflect upon what they know, the skills they have, and how their personal background and culture are assets in ways they may not have considered before, and in so doing ePortfolio pedagogy promotes student success.

Though in their infancy, the ePortfolio programs at SCU and A&M-SA hold great promise to aid students as they progress through their majors from freshmen to graduates and beyond. Some programs use ePortfolios to replace an existing discussion board or to display student prototypes in an engineering class. The benefits of ePortfolios are immense from allowing students to spread their creative wings, learn the technology, and create a personal space in which to demonstrate their learning. Today's students are increasingly interested in using technology from Snapchat to Tik Tok and they can integrate social media, videos, and other modes of expression into the ePortfolios. We believe that today's post-COVID-19 students are more adept at digital media than ever before. ePortfolios offer an opportunity to leverage students' increased technical prowess and to integrate this into their classroom experience in ways we haven't done before. Such application and integration of skills, and skill development from inside and outside the classroom would advance student success.

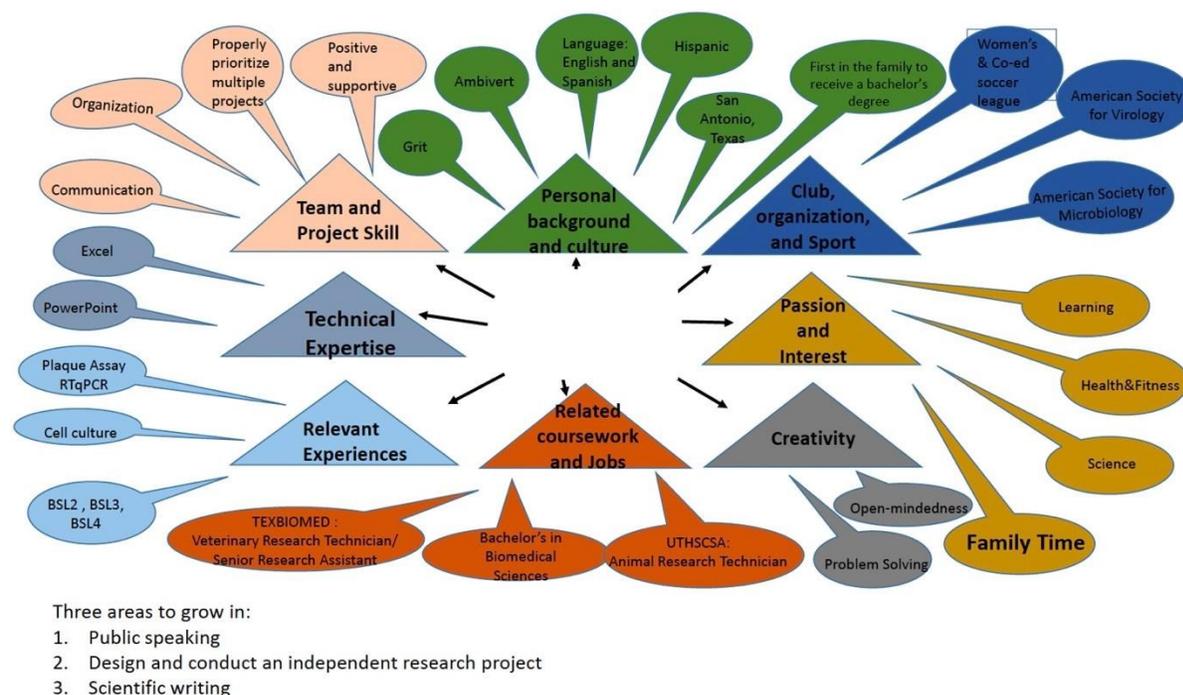


Figure 5: An image from a graduate student's ePortfolio entry showing their Asset Map

## Discussion: What Is It about ePortfolios That Promotes Equity, Engaged Learning, and Professional Identity Development?

As our examples illustrate, ePortfolios align well with research from the learning and developmental sciences and can be tailored to different student ability levels or developmental stages, as shown in our examples from first year to masters-level courses. As they appear to facilitate metacognitive awareness and improve self-efficacy, they align with the pedagogical approaches of SENCER, KEEN, and other professional organizations that promote STEM education. We consider that when done well, as evidenced in the value propositions we described, and in an inclusive pedagogical framework, ePortfolios make learning visible in ways that traditional assessment tools cannot. Through the students own words and reflections, we as instructors can see evidence of increased belonging and comfort with the material (Figure 2, Figure 3) engaged, deep learning (Figure 2, Figure 3, and Figure

5) and professional identity development (Figure 4 and Figure 5) which we consider as hallmarks of the achievement of value propositions 1 and 2. As we continue to incorporate ePortfolios across the curriculum in our institutions, particularly in developing programs such as our new master's degree programs, we anticipate that more underrepresented students will persist in STEM fields and that we'll be able to achieve institutional transformation (value proposition 3) in the use of these valuable, alternative assessment tools for STEM programs.

However, at the core of our teaching philosophy is our focus on inclusive learning to create student-centered learning environments where all students, including those who are traditionally underrepresented in STEM fields can succeed. Unless our students feel included and develop a sense of belonging, they will not be receptive to the reflective work that ePortfolio professional identity development requires for students to persist and be successful in their chosen STEM fields. We believe that ePortfolio pedagogy is most effective when implemented in a supportive classroom environment in a program or institution that is focused on student success.

We encourage further study into the potential affordances of ePortfolios for promoting inclusive classrooms, engaged learning and professional identity development in STEM, leading to increased retention and resulting in increased equity and inclusion. Despite the difficulties of randomized controlled ePortfolio interventions because of the complexity of controlling for numerous variables and financial constraints, further research is needed to evaluate the potential benefits of using the values framework for ePortfolio pedagogy in STEM education. Studies we would like to encourage include an exploration of intersectionality that includes not just race and economic or first-generation status but also gender, sexuality, and disability. Other studies might compare outcomes for first-year courses versus upper-division ones. Another option would be to research how aspects of belonging could be described, fostered, and measured in ePortfolios. And finally, we would like to see more research that highlights the students' voices and that can show gains over time or in comparison between ePortfolio pedagogy and control sections.

## Conclusion

ePortfolios are still an under-utilized resource in STEM. When implemented in the context of a welcoming and supportive classroom environment and according to the values framework to ensure student success, they have the potential to be helpful for all students, particularly those from minority populations, who—despite hoped-for careers in STEM fields—can find themselves switching out of science and engineering majors or dropping out of college altogether. Although there are no easy fixes to reverse this trend, we have suggested that ePortfolio pedagogy in conjunction with other HIPs can promote equity, engaged learning, and professional development. Our examples from our institutions demonstrate the utility and adaptability of ePortfolios to promote equity and inclusion, facilitate engaged learning, and support professional identity development. ePortfolio pedagogy also aligns well with other forms of engaged science education pedagogies, such as those advocated by SENCER, AAAS, and KEEN. There remains much research to be done.

## References

- Altun, Sertel, & Erden, Münire. (2013, December 10). Self-regulation based learning strategies and self-efficacy perceptions as predictors of male and female students' mathematics achievement. *Procedia - Social and Behavioral Sciences*, 106, 2354–2364. <https://doi.org/10.1016/j.sbspro.2013.12.270>
- Bandura, Albert, & National Institute of Mental Health. (1986). *Social foundations of thought and action: A social cognitive theory* (pp. xiii, 617). Prentice-Hall, Inc.
- Bandura, Albert. (1997). *Self-efficacy: The exercise of control*. Freeman.

- Batson, Trent, Coleman, Katherine S., Chen, Helen L., Watson, C. Edward, Rhodes, Terrel L., & Harver, Andrew. (Eds.). (2017). *Field guide to eportfolio*. Washington, D.C.: Association of American Colleges and Universities.
- Blakeslee, Ann M., Cole, Caroline M., & Conefrey, Theresa. (1996). Evaluating qualitative inquiry in technical and scientific communication: Toward a practical and dialogic validity. *Technical Communication Quarterly*, 5(2), 125–149. [https://doi.org/10.1207/s15427625tcq0502\\_1](https://doi.org/10.1207/s15427625tcq0502_1)
- Bowman, Jim, Lowe, Barbara J., Sabourin, Katie, & Sweet, Catherine Salomon. (2016). The use of ePortfolios to support metacognitive practice in a first-year writing program. *International Journal of ePortfolio*, 6(1), 1–22.
- Bryant, Lauren H., & Chittum, Jessica R. (2013). ePortfolio effectiveness: A(n Ill-fated) search for empirical support. *International Journal of ePortfolio*, 3(2), 189–198.
- Budwig, Nancy. (2013). The learning sciences and liberal education. *Change: The Magazine of Higher Learning*, 45(3), 40–48. <https://doi.org/10.1080/00091383.2013.787271>
- Callahan, Janet, & Belcheir, Marcia. (2017). Testing our assumptions: The role of first course grade and course level in mathematics and english. *Journal of College Student Retention: Research, Theory & Practice*, 19(2), 161–175. <https://doi.org/10.1177/1521025115611620>
- Cisco, Jonathan. (2020). Exploring the connection between impostor phenomenon and postgraduate students feeling academically-unprepared. *Higher Education Research & Development*, 39(2), 200–214. <https://doi.org/10.1080/07294360.2019.1676198>
- Conefrey, Theresa. (2017). LEADing the way with ePortfolios in a first-generation learning community. *International Journal of ePortfolio*, 7(2), 161–173.
- Conefrey, Theresa, & Smyth, Davida. (2020). Reflecting, integrating, and communicating knowledge through ePortfolios to increase civic and scientific literacy. *International Journal of ePortfolio*, 10(1), 1–18.
- Conefrey, Theresa, & Smyth, Davida S. (2021). High-impact practices for transforming online learning. *Journal of Higher Education, Theory and Practice*, 21(6). <https://doi.org/10.33423/jhetp.v21i6.4377>
- Crenshaw, Kimberle. (1989) Demarginalizing the intersection of race and sex: A black feminist critique of antidiscrimination doctrine, feminist theory and antiracist politics. *University of Chicago Legal Forum*, 1989. <https://chicagounbound.uchicago.edu/uclf/vol1989/iss1/8>
- David, E. J. R. (Ed.). (2014). *Internalized oppression: The psychology of marginalized groups*. Springer.
- Dewey, John. (1933). *How we think: A restatement of the relation of reflective thinking to the educative process*. Boston, MA: D.C. Heath & Co.
- Dweck, Carol S. (2006). *Mindset: The new psychology of success*. Random House.
- Equity and Inclusive Excellence—Texas A&M University-San Antonio*. (n.d.). <https://artsci.tamu.edu/about/equity-inclusion/index.html>
- Eynon, Bret, & Gambino, Laura M. (2017). *High-impact ePortfolio practice: A Catalyst for Student, Faculty, and Institutional Learning (1st ed.)*. Routledge.
- Eynon, Bret, & Gambino, Laura M. (2018). *Catalyst in action: Case studies of high-impact ePortfolio practice*. Routledge.
- Falco, Lia D., & Summers, Jessica J. (2019). Improving career decision self-efficacy and STEM self-efficacy in high school girls: Evaluation of an intervention. *Journal of Career Development*, 46(1), 62–76. <https://doi.org/10.1177/0894845317721651>
- Falconer, Heather M. (2022). *Masking inequity with good intentions: Systematic bias, counterspaces, and discourse acquisition in STEM education*. The WAC Clearinghouse; University Press of Colorado. <https://wac.colostate.edu/docs/books/masking/front.pdf>
- Finley, Ashley, & McNair, Tia. (2013). *Assessing underserved students' engagement in high-impact practices*. Association of American Colleges and Universities.
- Fry, Richard, Kennedy, Brian, & Funk, Cary. (2021, April 1). STEM jobs see uneven progress in increasing gender, racial and ethnic diversity. *Pew Research Center Science & Society*. <https://www.pewresearch.org/science/2021/04/01/stem-jobs-see-uneven-progress-in-increasing-gender-racial-and-ethnic-diversity/>

- Fuller, Karla. (2017). Beyond reflection: Using ePortfolios for formative assessment to improve student engagement in non-majors introductory science. *The American Biology Teacher*, 79(6), 442–449. <https://doi.org/10.1525/abt.2017.79.6.442>
- Gonzales, Sandra M., Brammer, Ethriam Cash, & Sawilowsky, Shlomo. (2015). Belonging in the academy: Building a “casa away from casa” for latino/a undergraduate students. *Journal of Hispanic Higher Education*, 14(3), 223–239. <https://doi.org/10.1177/1538192714556892>
- Hagerty, Bonnie M., Lynch-Sauer, Judith, Patusky, Kathleen L., Bouwsema, Maria, & Collier, Peggy. (1992, June). Sense of belonging: A vital mental health concept. *Archives of Psychiatric Nursing*, 6(3), 172–177. [https://doi.org/10.1016/0883-9417\(92\)90028-H](https://doi.org/10.1016/0883-9417(92)90028-H)
- Harrison, Colin, & Tanner, Kimberly D. (2018, March 22). Language matters: Considering microaggressions in science. *CBE—Life Sciences Education*, 17(1). <https://doi.org/10.1187/cbe.18-01-0011>
- Hubert, David, Pickavance, Jason, & Hyberger, Amanda. (2015, October 1). *Reflective e-Portfolios: One HIP to rule them all?* <https://www.semanticscholar.org/paper/Reflective-E-Portfolios%3A-One-HIP-to-Rule-Them-All-Hubert-Pickavance/af25d89330cc13da79228a05f62c4ec24241a142>
- Katreovich, Alina V., & Aruguete, Mara S. (2017, June). Recognizing challenges and predicting success in first-generation university students. *Journal of STEM Education: Innovations and Research*, 18(2), 40–44.
- Kezar, Adrianna, Holcombe, Elizabeth, Vigil, Darsella, & Mathias Dizon, Jude Paul. (2021). Shared equity leadership: Making equity everyone’s work. Washington, DC: American Council on Education; Los Angeles: University of Southern California, Pullias Center for Higher Education.
- Kuh, George D. (2008). *High-impact educational practices: What they are, who has access to them, and why they matter*. Association of American Colleges and Universities.
- Kuh, George D., O’Donnell, Ken, Reed, Sally D. Association of American Colleges and Universities, & Liberal Education and America’s Promise. (2013). *Ensuring quality & taking high-impact practices to scale*. AAC&U, Association of American Colleges and Universities.
- Ladson-Billings, Gloria. (1998). Just what is critical race theory and what’s it doing in a nice field like education? *International Journal of Qualitative Studies in Education*, 11(1), 7–24. <https://doi.org/10.1080/095183998236863>
- Laldin, Myra. (2016, February 11). The psychology of belonging (and why it matters). *Learning & the Brain*. <https://www.learningandthebrain.com/blog/psychology-of-belonging/>
- Lent, Robert W., Miller, Matthew J., Smith, Paige E., Watford, Bevelee A., Hui, Kayi, & Lim, Robert H. (2015, February). Social cognitive model of adjustment to engineering majors: Longitudinal test across gender and race/ethnicity. *Journal of Vocational Behavior*, 86, 77–85. <https://doi.org/10.1016/j.jvb.2014.11.004>
- Lent, Robert W., Miller, Matthew J., Smith, Paige E., Watford, Bevelee A., Lim, Robert H., Hui, Kayi, Morrison, M. Ashley, Wilkins, Gregory, & Williams, Kevin. (2013, August). Social cognitive predictors of adjustment to engineering majors across gender and race/ethnicity. *Journal of Vocational Behavior*, 83(1), 22–30. <https://doi.org/10.1016/j.jvb.2013.02.006>
- Lukitasari, Marheny., Hasan, Rusdi, & Sukri, Akhmad. (2020, January). The effect of e-Portfolio on biological concepts understanding and responses of students with different academic achievement levels. *International Journal of Instruction*, 13(1), 685–694. <https://doi.org/10.29333/iji.2020.13144a>
- Marcia, James E., Waterman, Alan S., Matteson, David R., Archer, Sally L., & Orlofsky, Jacob L. (1993). *Ego identity: A Handbook for Psychosocial Research*. Springer. <https://doi.org/10.1007/978-1-4613-8330-7>
- NRC Strategic Planning Committee. (2021). *NRC Strategic Plan 2021-2026*. National Academies of Sciences, Engineering, Medicine. <https://www.nationalacademies.org/documents/embed/link/LF2255DA3DD1C41C0A42D3BEF0989ACAECE3053A6A9B/file/DB4DC1F0F8C6D4707DAA110A4790523122A000124DB5?noSaveAs=1>
- Office for Diversity and Inclusion—Santa Clara University. (n.d.). <https://www.scu.edu/diversity/>
- Okrent, Abigail, & Burke, Amy. (2021, August). The STEM labor force of today: Scientists, engineers, and skilled technical workers. *The National Science Board; The National Science Foundation*. <https://nces.nsf.gov/pubs/nsb20212>

- Penny Light, Tracy, Chen, Helen L., & Ittelson, John C. (2011). *Documenting learning with ePortfolios: A guide for college instructors* (1st ed.). Jossey-Bass.
- Polly, Patsie, Coleman, Kathryn, Fath, Thomas, Thai, Thuan, & Yang, Jia-Lin. (2020). The learner-teacher portfolio journey: Developing self-efficacy and self-determination in the medical sciences. *The WAC Clearinghouse; University Press of Colorado*, 125-145.
- Pratt, Ian S., Harwood, Hunter. B., Cavazos, Jenel T., & Ditzfeld, Christopher P. (2019). Should I stay or should I go? Retention in first-generation college students. *Journal of College Student Retention: Research, Theory & Practice*, 21(1), 105–118. <https://doi.org/10.1177/1521025117690868>
- Reynolds, Candyce, Patton, Judith, & Rhodes, Terry. (2014). *Leveraging the ePortfolio for integrative learning: A faculty guide to classroom practices for transforming student learning* (1st ed.). Stylus. [https://rutgers.primo.exlibrisgroup.com/discovery/fulldisplay/alma991031328918604646/01RUT\\_IN ST:01RUT](https://rutgers.primo.exlibrisgroup.com/discovery/fulldisplay/alma991031328918604646/01RUT_IN ST:01RUT)
- Ridlo, Saiful, & Lutfiya, Fina. (2017). The correlation between metacognition level with self-efficacy of biology education college students. *Journal of Physics: Conference Series*, 824(1). <https://doi.org/10.1088/1742-6596/824/1/012067>
- Rodgers, Carol. (2002, June). Defining reflection: Another look at John Dewey and reflective thinking. *Teachers College Record*, 104(4), 842-866. <https://doi.org/10.1111/1467-9620.00181>
- Singer-Freeman, Karen, & Bastone, Linda. (2017). Changing their mindsets: ePortfolios encourage application of concepts to the self. *International Journal of ePortfolio*, 7(2), 151–160.
- Singer-Freeman, Karen, & Bastone, Linda. (2019). Developmental science concepts guide effective support of underrepresented STEM students. *Biochemistry and Molecular Biology Education*, 47(5), 506–512. <https://doi.org/10.1002/bmb.21292>
- Singer-Freeman, Karen, Bastone, Linda, & Skrivanek, Joseph. (2014). ePortfolios reveal an emerging community of underrepresented minority scholars. *International Journal of ePortfolio*, 4(1), 85–94.
- Singer-Freeman, Karen, Bastone, Linda, & Skrivanek, Joseph. (2016). Using ePortfolios to assess applied and collaborative learning and academic identity in a summer research program for community college students. *International Journal of ePortfolio*, 6(1), 45–57.
- Sithole, Alec, Chiyaka, Edward T., McCarthy, Peter, Mupinga, Davidson M., Bucklein, Brian K., & Kibirige, Joachim. (2017). Student attraction, persistence and retention in STEM programs: successes and continuing challenges. *Higher Education Studies*, 7(1), 46–59.
- [Smyth, Davida S., Chen, Simon, Sompanya, Geena, Metz, Molly, & Conefrey, Theresa. \(n.d.\). How getting friendly with bacteria can promote student appreciation of microbial diversity and their civic scientific literacy. \*Journal of Microbiology & Biology Education\*, 23\(2\). <https://doi.org/10.1128/jmbe.00055-22>](#)
- Spencer, Steven. J., Steele, Claude M., & Quinn, Diane M. (1999). Stereotype threat and women's math performance. *Journal of Experimental Social Psychology*, 35(1), 4–28. <https://doi.org/10.1006/jesp.1998.1373>
- Sue, Derald Wing., Alsaidi, Sarah, Awad, Michael N., Glaeser, Elizabeth, Calle, Cassandra. Z., & Mendez, Narolyn. (2019). Disarming racial microaggressions: Microintervention strategies for targets, White allies, and bystanders. *The American Psychologist*, 74(1), 128–142. <https://doi.org/10.1037/amp0000296>
- Tinto, Vincent. (2017). Through the eyes of students. *Journal of College Student Retention: Research, Theory & Practice*, 19(3), 254–269. <https://doi.org/10.1177/1521025115621917>
- Tukibayeva, Malika, & Gonyea, Robert. M. (2014). High-impact practices and the first-year student. *New Directions for Institutional Research*, 2013(160), 19–35. <https://doi.org/10.1002/ir.20059>
- Watson, C. Edward., Kuh, George. D., Rhodes, Terrel., Penny Light, Tracy, & Chen, Helen. L. (2016). Editorial: ePortfolios – the Eleventh High-Impact Practice. *The International Journal of ePortfolio*, 6(2), 59–65.
- Wiedemann, Christin. (2019). Why diversity is crucial to success in STEM. CERIC. <https://ceric.ca/2019/02/why-diversity-is-crucial-to-success-in-stem/>

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